



**Water Treatment Technology
Feasibility Support Document
for Chemical Contaminants; In
Support of EPA Six-Year
Review of National Primary
Drinking Water Regulations**

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In Support of EPA Six-Year Review of
National Primary Drinking Water Regulations**

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ACRONYMS

µg/L	Micrograms per liter
BAT	Best available technology
BTGA	Best technology generally available
CFR	Code of Federal Regulations
CWS	Community water system
CWSS	Community Water System Survey
EPA	United States Environmental Protection Agency
FR	<i>Federal Register</i>
GAC	Granular activate carbon
GFH	Granular ferric hydroxide
LCR	Lead and Copper Rule
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
mg/L	Milligrams per liter
NPDWR	National Primary Drinking Water Regulation
PAC	Powdered activated carbon
POE	Point-of-entry
POU	Point-of-use
PQL	Practical quantitation level
PTA	Packed tower aeration
SDWA	Safe Drinking Water Act
SnCl ₂	Stannous chloride
TCLP	Toxicity characteristic leaching procedure
TCR	Total Coliform Rule
TT	Treatment technique
USEPA	United States Environmental Protection Agency
VOC	Volatile organic chemical

I. Introduction

This water treatment technology feasibility support document summarizes available treatment feasibility information in support of the United States Environmental Protection Agency (EPA) review of National Primary Drinking Water Regulations (NPDWRs). A review of NPDWRs is required at least once every six years under section 1412(b)(9) of the Federal Safe Drinking Water Act (SDWA), as amended in 1996. The 1996 to 2002 Six-Year Review of NPDWRs addresses 68 regulated chemical contaminants (*i.e.*, most of the chemical contaminants regulated prior to 1996), in addition to the Total Coliform Rule (TCR). This document supports EPA's review decisions on the chemical contaminants, but it does not address the TCR review decision, which is documented separately.

EPA sets non-enforceable maximum contaminant level goals (MCLGs), based on health effects information and related risk analyses. EPA enforceable standards include maximum contaminant levels (MCLs) and treatment techniques (TTs) which are dependent upon EPA-documented treatment feasibility assessments and other considerations.

EPA developed a systematic approach or protocol for the review of these NPDWRs (USEPA, 2003a). Several technical analyses were completed by EPA in the 1996 to 2002 review of chemical NPDWRs. In addition to water treatment technologies, the analyses addressed human health effects of the subject contaminants, analytical methods, chemical occurrence, and other aspects related to the regulations. These analyses were conducted individually and are documented separately. They are referenced in this report, as appropriate.

Results of the above-cited analyses were used by EPA to make a preliminary determination as to which NPDWRs may be appropriate for revision (*i.e.*, the analyses identified possible or potential candidates for revision based upon the review of new scientific data). On April 17, 2002, EPA published its preliminary findings in the *Federal Register* (67 FR 19030 (USEPA, 2002a)). That was followed by a public comment period, during which EPA received comments on its review of NPDWRs, including the review of treatment feasibility. EPA responded to these comments in the *Public Comment and Response Summary for the Six-Year Review of National Primary Drinking Water Regulations* (USEPA, 2003d), and in a subsequent *Federal Register* notice.

This document contains similar material as the earlier draft report that was developed in support of the Agency's preliminary findings (USEPA, 2002b). However, it has been augmented with information presented and discussed in public comments on EPA's April *Federal Register* notice. With this and other new information that became available since April 2002, discussions were added in two latter sections of the document which were not included in the earlier draft technology report. In addition, section VIII of this report incorporates a summary of potential treatment-related research areas. The potential water treatment research areas stemmed from EPA's review of available information, including public comments. This list will be used to inform and guide EPA's internal research strategy and may be further discussed with external parties, (*i.e.*, EPA stakeholders), as appropriate. Results of appropriate treatment research, whether initiated by the Agency or by others, would be used in support of future reviews of NPDWRs.

In terms of the process EPA has followed in determining which standards require a technology feasibility review, the Agency focused on individual NPDWRs if either of the following conditions applied:

- A health effects technical review suggested a potential change to the MCLG; or,
- A health effects assessment was not in process (or scheduled) for the contaminant and one of the following conditions applied: (1) the analytical feasibility assessment suggests a potential revision to the regulated level; (2) the NPDWR is a TT-type rule.

In addition, EPA reviewed treatment feasibility information for NPDWRs for which the best available technology (BAT) or TT requirements were not clear or were incorrectly specified (*one* such NPDWR was identified) and information that EPA received during the comment period following publication of the April 17, 2002, *Federal Register* notice (67 FR 19030 (USEPA, 2002a)). Some new treatment information was supplied to EPA for the contaminant antimony as part of the public comments on that notice. Table 1, below, lists the chemical NPDWRs discussed in this report. This tabulation has been updated since the draft report was released, incorporating NPDWRs for which new EPA health assessments were anticipated in 2002 or 2003.

Table 1. Chemical NPDWRs Included in This Treatment Feasibility Document			
Contaminants Identified Under the Six-Year Health Effects Review			
1	Beryllium	4	Oxamyl
2	Chromium (total)	5	Picloram
3	Fluoride		
Contaminants for Which Analytical Feasibility Assessments Suggested a Potential Change			
1	Benzene	8	Heptachlor epoxide
2	Carbon tetrachloride	9	Hexachlorobenzene
3	Chlordane	10	Tetrachloroethylene ("perc")
4	1,2-Dibromo-3-chloropropane (DBCP)	11	Thallium
5	1,2-Dichloroethane	12	Toxaphene
6	Dichloromethane	13	1,1,2-Trichloroethane
7	1,2-Dichloropropane	14	Trichloroethylene
Contaminants Regulated by TT Requirements			
1	Acrylamide	3	Epichlorohydrin
2	Copper	4	Lead
Contaminant for Which BAT Is Not Clear or Is Incorrectly Specified			
Cyanide			
Contaminant for Which Public Comments Provided New Information¹			
<i>Antimony²</i>			
Contaminants for Which Health Assessments Were Anticipated in 2002 or 2003¹			
1	<i>1,1-Dichloroethylene</i>	3	<i>Toluene²</i>
2	<i>Lindane</i>	4	<i>Xylenes²</i>
1. Italicized print indicates chemicals for which new information was anticipated to be available in 2002 or 2003, (<i>i.e.</i> , information not discussed in the February draft report or the April <i>Federal Register</i> notice).			
2. Indicates contaminants for which new health assessments had not been completed as of January 2003.			

This document primarily discusses BATs specified by EPA to meet MCLs, and technologies to meet TT-type rules. Supplemental information is provided on small systems compliance technologies and other related treatment information. In addition, EPA has included, as appropriate, the following: available EPA data on treatment technologies in place at community water systems, (*i.e.*, some baseline treatment characteristics; discussion of the feasibility of adding treatment or modifications to existing in-place treatments; discussion of treatment wastes as appropriate; and, general characterization of research areas that may be pursued prior to revising an NPDWR) although, such characterization of potential research is not meant to be exhaustive in nature, nor static. EPA is relying on available scientific and engineering data to support this process. The end result of each contaminant-specific review which follows is a determination of whether treatment would pose a limitation should EPA pursue a revision to a specified standard.

This treatment review contains some recent information related to the EPA-estimated occurrence of chemical contaminants (*i.e.*, levels above current MCL and other threshold

values). These indicators of contaminant levels in drinking water may be relevant in the assessment of feasibility of treatment or of making treatment modifications. Since EPA has not decided to revise the MCLs for the contaminants reviewed in this document, this support document does not contain nor assume any particular revised MCL values. The purpose of this report is to review available information on treatment feasibility related to any potential EPA revise/not revise decisions on the NPDWRs.

As mentioned above, this treatment technology document identifies areas of water treatment research which may be required if EPA were to consider revisions to a standard. These are identified in sections II and III, in relation to chemical MCL and TT-type rules, respectively. Section IV, related to MCL-type rules for which analytical assessment indicated the potential for lowering a standard, does not contain research suggestions, as none have been identified.

The Agency is also including a discussion of potential water treatment technology in this document to inform both the EPA drinking water program and the public. This information will be considered within EPA's research planning process, with the longer-term aim of strengthening regulations such that they may be more effective and implementable. Research suggestions may also be aimed at defining new technologies that are emerging in the field, and for qualifying their possible application to specific NPDWRs, thus providing technical information to improve one or more aspects of treatment. The Agency continually addresses such needs, and each new assessment of needs and resources available typically results in a modification to the research priorities.

Ideally, research on the treatment technologies will result in specific advantages, such as lower-cost treatments, and/or easing burdens associated with operation and maintenance. As necessary, research may be targeted to meet the needs of certain types of water systems, (e.g., small water systems), or to address multiple water quality issues. Potential research areas identified during this review are indicated at the end of each chemical discussion in sections II and III, and summarized in section VIII of this document.

In addition to research, other processes are in place to assist in the upgrading of treatment technology information. Among these are the Agency's periodic review of water treatment technologies for NPDWRs, the first of which was completed, for chemical NPDWRs, in 1998 (USEPA, 1998b). Per SDWA as amended in 1996, that review focused on small systems compliance technologies. EPA is committed to periodic review of small systems compliance technologies, and intends to supplement that with review of new information on emerging technologies that may be appropriate and affordable for meeting existing standards, for both small- and large-scale drinking water systems.

II. Treatment Reviews for MCL-type Standards for Which Health Risk Assessments Were Completed or Anticipated

The following contaminants were identified by EPA for treatment technology review because new health risk information was available (*i.e.*, beryllium, oxamyl and picloram), or because *new* scientific reviews were anticipated (*i.e.*, chromium and fluoride).

A. Beryllium

Recent EPA occurrence analyses estimated beryllium occurrence in public water systems based on a sampling of 16 States (USEPA, 2003b). Based on these analyses, EPA estimates indicate a total of 15 water systems (credible interval of 7 to 24)¹ within these States may have a system mean concentration exceeding the threshold of 0.004 milligrams per liter (mg/L), (*i.e.*, the current MCL for beryllium). Additional occurrence estimates may be found in the above-cited 2003 EPA report.

The current BATs for beryllium removal include activated alumina, ion exchange, lime softening, coagulation/filtration, and reverse osmosis (USEPA, 1990b; USEPA, 1990c; 57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). Compliance technologies for small systems include these same five BATs, plus point-of-use (POU)-reverse osmosis, POU-ion exchange for small systems (USEPA, 1998b). Removal efficiencies for the above-cited BATs range from 80 to 99 percent. Treatment technologies were discussed by EPA in its technical support documentation on beryllium (USEPA, 1990c). If a treatment plant were to require upgrading, additional ion exchange contact units may be added, POU treatment installed, or a modification to precipitative processes added, as appropriate. The Agency's current assessment is that treatment technology would not pose a limitation, should EPA pursue a revision to this standard.

The current BATs and small system compliance technology for beryllium also apply to other contaminants. These treatment technologies have other beneficial effects (e.g., reduction of hardness or other common impurities) in addition to beryllium removal. If EPA were to consider a higher MCL, the Agency does not know how many of these public water systems currently treating to comply with the current MCL of 0.004 mg/L would be likely to discontinue any treatment that is already in place.

B. Chromium (Total)

1. Treatment technology

Recent EPA occurrence analyses indicate chromium occurrence in public water systems based on a sampling of 16 States (USEPA, 2003b). Based on these analyses, EPA estimates indicate that one water system (credible interval of 0 to 3) within these States may have a system mean concentration exceeding the threshold of 0.1 mg/L, the current MCL for total chromium. In addition, EPA estimates indicate a total of seven systems (credible interval of 3 to 13) within these States may exceed the threshold of 0.05 mg/L. Additional occurrence estimates may be found in the above-cited 2003 EPA report.

In publishing the 1989 proposed and 1991 final chromium standard (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)) the Agency discussed BATs which include:

- Ion exchange: 80 to 96 percent efficiency;

¹ "Credible intervals" are generated to quantify the uncertainty around each estimated probability in the Bayesian analysis of the occurrence data. For further explanation of credible intervals and the Bayesian analysis, please see *Occurrence Estimation Methodology and Occurrence Findings Report for the Six-Year Review of Existing National Primary Drinking Water Regulations* (USEPA, 2003b).

- Lime softening for chromium III only: 72 to 99 percent efficiency;
- Coagulation/filtration: 90 to 99 percent efficiency; and
- Reverse osmosis: 82 to 97 percent efficiency.

Due to the ionic properties of the two chromium species in water, chromium III and chromium VI, there is a differentiation in BAT specification which may affect treatment selection. Chromium III and chromium VI exist in water in cationic and anionic valence states, respectively. Lime softening treatment is excluded as a BAT for anionic chromium VI. Regarding the coagulation/filtration option, the choice of coagulant will impact chromium III and chromium VI removal. Ferric sulfate and alum are effective for removal of chromium III, while ferrous sulfate is effective for removal of chromium VI. Regarding ion exchange, a cation exchange resin is required for chromium III, while an anionic resin is required for chromium VI. Therefore, prior to use (or modification) of lime softening, ion exchange, or coagulation/filtration treatment, a public water system should determine concentrations and proportions of species of chromium to select proper media or chemical aid.

The 1996 SDWA Amendments require EPA to determine small system technologies for compliance purposes, (*i.e.*, technology designated as suitable for systems serving 25 to 10,000 persons). In 1998, EPA listed the following compliance technologies for small systems: ion exchange, lime softening (chromium III only), coagulation/filtration, reverse osmosis, POU-reverse osmosis, and POU-ion exchange (USEPA, 1998b).

Due to the high efficiencies of chromium removal by the above technologies, EPA believes that existing BATs would be adequate in meeting a revised standard (if the standard were lowered). Thus, the Agency's current assessment is that treatment technology would not pose a limitation should EPA pursue a revision to the chromium standard.

Due to recent interest by the State of California in setting a drinking water standard for chromium VI (the more toxic form of chromium), that State and others have initiated treatment studies to determine the efficacy of treatment technologies in removal of chromium VI to levels that are lower than the federal standard for total chromium. Newer treatments of interest include an iron-based absorptive filter medium, granular ferric hydroxide (GFH), a technology that has been piloted for arsenic removal at California water systems, and in the United Kingdom. Also, a treatment to reduce low levels of chromium VI to chromium III in drinking water by addition of the chemical stannous chlorine (SnCl_2) is currently under investigation at a water system in Glendale, California. EPA will monitor treatment studies to determine acceptability for use in removal of chromium from drinking water.

2. Additional information

Of additional interest to EPA is the likelihood that disinfection treatment, including chlorination, plays a role in transforming, by oxidation, chromium III to chromium VI in water. The EPA *Manual of Treatment Techniques for Meeting the Interim Primary Drinking Water Regulations* (USEPA, 1977) and the EPA *Occurrence and Exposure Assessment for Chromium in Public Drinking Water Supplies* (USEPA, 1990a) discussed effects of chlorination on chromium III in raw water (spiked) and in finished water. EPA found that time of contact, pH and other factors influence oxidation of the species. In addition, a Health Canada criteria summary on chromium in drinking water also indicated uncertainty with respect to whether post-treatment with chlorine, affecting conversion of residual chromium III to chromium VI, may

reverse as water passes through iron pipes in the distribution system (Health Canada, 1986). The testing in Glendale, California of stannous chloride as a chromium VI mitigation treatment also includes investigation of re-oxidation of chromium III to chromium VI under various chlorination and ammoniation treatment disinfection scenarios. While the above information provides a minimum baseline of information on potential transformations of chromium species, more information may be required regarding these and other potential treatment effects.

In regard to small system technologies, EPA will review available information on newer potential treatments as research and field studies are undertaken and publicized. EPA may also need additional data on issues related to POU-ion exchange treatment, which the Agency discussed in a January 2001 (arsenic) *Federal Register* notice (66 FR 6975 at 7034, January 22, 2001 (USEPA, 2001a)). Without additional data, the Agency cannot determine if POU-ion exchange will be a feasible compliance option, due to operational and waste discharge concerns, and related economic issues.

3. Potential in-place treatment modifications

EPA has previously published analyses of data collected in the 1995 Community Water System Survey (CWSS) on treatment in place at community water systems (USEPA, 2000a as cited in USEPA, 2001b). The data indicate that a majority of larger systems, and mainly surface water supplied systems, are much more likely to have coagulation/filtration or lime softening treatment in place. Some of these systems may need to modify existing treatment to allow for more efficient removal of chromium to comply with a more stringent chromium standard. For example, an existing lime softening plant may need to enhance the process to operate at a pH of 11 to 11.5 for optimum removal; or an existing coagulation/filtration plant may need to change to ferric or ferrous coagulant to lower chromium levels in drinking water. The CWSS data also indicate that small systems may need to modify or add new centralized treatment or POU treatment to meet a standard.

The option of modifying existing treatment may be possible for a limited number of systems, as 0.7 to 4.6 percent of small ground water systems currently have ion exchange treatment in place. Most of these are likely to be cationic resin types (whereas anionic resins may be required to remove excess chromium), and virtually none of the small surface water supplies have this treatment in place. A large percentage of small (and nearly all large) surface water supplies have either coagulation/filtration or lime softening treatment in place, whereas only 1.5 to 8.1 percent of small ground water systems currently have coagulation/filtration or lime softening treatment in place. However, given the occurrence information, it appears that the majority of treatment upgrades would occur at small ground water systems, many requiring new treatments, possibly pressurized, packaged treatment technology or other emerging treatments mentioned above.

Tables 2a and 2b, below, contain results of the above-cited 1995 CWSS data analyses and are provided for reference.

Table 2a. Ground Water Systems: Percentage of CWSs with Various Types of Treatment¹

Treatment Types	Service Population Category				
	25-100	101-500	501-1,000	1,001-3,300	3,301-10,000
Ion Exchange	0.7%	1.6%	3.8%	1.9%	4.6%
Coagulation/Filtration	1.5%	5.4%	4.2%	3.4%	8.1%
Lime/Soda Ash Softening	2.1%	3.7%	4.1%	5.2%	7.0%

¹ Treatment information from 1995 Community Water System Survey as summarized in *Geometries and Characteristics of Public Water Systems* (USEPA, 2000a as cited in USEPA, 2001b).

Table 2b. Surface Water Systems: Percentage of CWSs with Various Types of Treatment¹

Treatment Types	Service Population Category				
	25-100	101-500	501-1,000	1,001-3,300	3,301-10,000
Ion Exchange	0%	0%	0%	0%	0%
Coagulation/Filtration	27.5%	52.6%	70.2%	78.5%	95.4%
Lime/Soda Ash Softening	3.9%	8.1%	20.5%	17.5%	10.8%

¹ Treatment information from 1995 Community Water System Survey as summarized in *Geometries and Characteristics of Public Water Systems* (USEPA, 2000a as cited in USEPA, 2001b).

4. Potential chromium treatment research

Prior to conducting analyses in support of an NPDWR revision, should a more stringent chromium MCL be considered, EPA would need to review literature and/or conduct new treatment research. This may include documentation of bench, pilot, and/or full-scale studies on GFH, other adsorption media, and membrane technologies. POU-ion exchange studies on chromium removal may be required, including tests on efficacy of treatment and disposal of related wastes. Studies may include optimization of centralized ion exchange treatment efficiency and waste treatment and handling/disposal. Effects of disinfection treatments, as well as addition of reducing agents such as SnCl₂ on chromium in water may require further study should a more stringent chromium MCL be considered. These needs would be forwarded to the appropriate office within EPA to be considered for research.

C. Fluoride

1. Treatment technology

Recent EPA occurrence analyses indicate fluoride occurrence in public water systems based on a sampling of 16 States (USEPA, 2003b). Based on these analyses, EPA estimates indicate that a total of 106 water systems (credible interval of 91 to 123) within these States may have a system mean concentration exceeding the threshold of 4 mg/L, the current MCL for fluoride. In addition, EPA estimates indicate a total of 603 (credible interval of 566 to 640) water systems within these States may exceed the threshold of 2 mg/L. Additional occurrence estimates may be found in the above-cited 2003 EPA report.

The 1986 final fluoride regulation set "best technologies generally available" (BTGAs) as activated alumina and reverse osmosis. BTGA was defined prior to the SDWA Amendments of 1986, based upon measures of technological efficiency and economic accessibility (*i.e.*, "reasonably affordable by regional and large metropolitan public water systems"). The following factors were considered in determination of BTGA: high removal rate; wide applicability; compatibility with other treatments; and ability to achieve compliance for all water in the public water system (51 FR 11396 at 11398, April 2, 1986 (USEPA, 1986)). These requirements are comparable with current SDWA requirements for BAT determination.

In addition, the 1996 SDWA amendments require EPA to determine small system technologies for compliance purposes, (*i.e.*, technology designated as suitable for systems serving 25 to 10,000 persons). In 1998, EPA listed small system compliance technologies, including both centralized activated alumina and reverse osmosis treatment, as well as POU-reverse osmosis, for removal of fluoride in drinking water (USEPA, 1998b).

The Agency does not believe that the "BTGA" or small systems compliance technologies pose a problem. In addition, should a revision to the designation of "BATs" for this contaminant be considered by EPA, in lieu of the originally specified "BTGA" designation, this would represent a minor revision to the NPDWR (see 40 CFR 141.62 for MCLs for Inorganic Contaminants; and 40 CFR 142.61, which specifies variance technologies for fluoride).

Previously published research and EPA technologies and costs documents (USEPA, 1985b) on these technologies indicate that, due to high efficiencies of removal, the above-cited treatment technologies would not be a limiting factor in setting a lower fluoride MCL. Efficiencies of removal range from 85 to 95 percent, depending upon treatment system design. Thus, the Agency's current assessment is that treatment technology would not pose a limitation should EPA pursue a revision to the fluoride standard.

Both activated alumina and reverse osmosis treatment remove arsenic *and* fluoride among other impurities. Using activated alumina treatment, optimum removals for both contaminants may occur in a similar range of pH 5.5 to pH 6 (USEPA, 1985b; USEPA, 2000b). However, because arsenic V and silica are preferentially adsorbed by activated alumina media, effectiveness of activated alumina where arsenic and fluoride co-occur may require some investigation. Another activated alumina treatment shortcoming, discussed further below, is the operational difficulty of adding pH adjustment for optimizing removal efficiency (*i.e.*, adjusting pH prior to and after treatment). For some small systems, treatment may be limited to using "natural" pH levels (*i.e.*, unadjusted) thus sacrificing some removal efficiency. However, this application for fluoride removal is not documented.

The Agency discussed technical issues related to activated alumina technology in the above-cited fluoride final rule, including waste generation and disposal. More recent EPA publications have also examined the operation of activated alumina technology and perceived difficulties posed by chemical handling by small systems, (*i.e.*, for pH adjustment and for regeneration of the media), as well as the alternatives to regeneration of activated alumina media. In the case of arsenic treatment, the Agency recommended against the regeneration of activated alumina media at both small centralized treatment and POU applications, due in part to the difficulty of disposing of brine wastes. EPA instead assumed that spent activated alumina media would be disposed of directly at a landfill on a "throw-away" basis and that, based upon arsenic toxicity characteristic leaching procedure (TCLP) testing, this waste would not be deemed

"hazardous" (USEPA, 2000b; 66 FR 6975, January 22, 2001 (USEPA, 2001a)). However, except where arsenic and fluoride were being co-treated, this information should not (alone) be applied to fluoride treatment wastes because Resource Conservation and Recovery Act (RCRA) regulations do not regulate fluoride under the toxicity characteristic hazardous waste identification rule (40 CFR 261.24). That stated, there may be concerns regarding waste brine (*i.e.*, regenerate solution) that have not yet been anticipated.

As part of recent revisions to the arsenic standard, the Agency also addressed the issue of treatment optimization (pH adjustment) for POU-activated alumina systems. For arsenic, EPA determined that use of POU (and point-of-entry (POE))-activated alumina would be limited due to the practical limitation of adjusting pH and then re-adjusting after treating for corrosion control. The Agency considered the option of using activated alumina at an *unadjusted* "natural pH" range of 7 to 8 as the probable application at *very* small systems due to the operational capabilities that are required to properly adjust pH (USEPA, 2000b; 66 FR 6975, January 22, 2001 (USEPA, 2001a)).

While not currently a "BTGA" or "BAT", modified lime softening (30 to 70 percent removal) may also be used where this treatment is in place to remove excess fluoride (USEPA, 1985b).

The following summarizes additional information that may relate to setting, revising, and/or applying the above two BATs and the POU compliance option for fluoride.

2. Potential in-place treatment modifications

Cost of treatment may drive systems that have fluoride above the compliance level to the less expensive option (*i.e.*, activated alumina), or to newer treatments as they become available. Where de-fluoridation treatment is already in place, due to prior exceedance of the current fluoride MCL, systems may opt to increase the proportion of water treated, or add more *capacity* to existing treatment (or additional media vessels in series). Because centralized treatment may be less economically feasible for very small systems, some may install POU treatment (with reverse osmosis being the more likely choice). POU treatment may also present operational advantages and additional treatment benefits. The BATs are known to remove fluoride and arsenic (arsenic V is preferentially adsorbed by activated alumina media). Reverse osmosis treatment would remove additional regulated and secondary contaminants, such as total dissolved solids, hardness, iron, and manganese, which may co-occur with fluoride in water.

EPA's 1995 CWSS data is summarized and has been utilized in recent EPA technical support materials (USEPA, 2000a as cited in USEPA, 2001b). These provide some understanding of numbers and types of treatments in place at community water systems. However, they do not specifically include activated alumina treatment information. Therefore, it is not possible to estimate a relationship between systems now treating with activated alumina, and those that may need to treat further to meet a lower standard. However, in areas with high background levels (especially if above 4 mg/L), treatment of fluoride may already be in place. The followup 2000 CWSS results are expected to include activated alumina treatment information and these will be available in the 2003 time frame.

The CWSS summary tables indicate (see Tables 2a and 2b) that lime/soda ash softening capacity exists and *may provide*, especially for surface water systems, a base for increased

fluoride removal via enhanced lime softening treatment.

3. Potential fluoride treatment research

Prior to conducting analyses in support of an NPDWR revision, if that were necessary, EPA would review pertinent literature and/or conduct new treatment research. In 2002, EPA initiated and drafted a literature review on fluoride treatment processes (which the Agency is maintaining in draft status, as it may require future updating) (USEPA, 2002c). Review of the literature, in the future, may lead to additional potential research areas. These may be further pursued through documentation of bench, pilot, and/or full-scale studies, related to treatment effectiveness; engineering studies on existing BATs; or other treatment processes. Documentation and/or study of waste treatment, handling and disposal, and POU treatment studies may also be required should a more stringent fluoride MCL be considered. These needs would be forwarded to the appropriate office within EPA to be considered for research.

Unrelated to the above potential fluoride treatment research, the Agency has initiated an investigation of the kinetics and equilibria of the chemicals used in water fluoridation. This work would contribute to the understanding of how fluoridation chemicals dissociate in finished water. The Agency funded this project, which is underway and expected to be completed in the 2005 time frame.

D. Oxamyl

Recent EPA occurrence analyses indicate oxamyl occurrence in public water systems based on a sampling of 16 States (USEPA, 2003b). Based on these analyses, EPA estimates indicate zero (number and percent) water systems within these States may have a system mean concentration exceeding the threshold of 0.2 mg/L, the current MCL for oxamyl. Additional occurrence estimates may be found in the above-cited 2003 EPA report.

The current BAT is granular activated carbon (GAC), and removal efficiency ranges from 85 to 95 percent depending upon design parameters (USEPA, 1990b; 55 FR 30370 at 30416, July 25, 1990 (USEPA, 1990d), 57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). Compliance technologies for small systems include: GAC, powdered activated carbon (PAC), and POU-GAC (USEPA, 1998b).

If water treatment systems were to require upgrading, additional GAC contactor(s) may be added or PAC added, as appropriate. Given available information on treatment efficacy and on occurrence levels, the Agency's current assessment is that treatment technology would not pose a limitation should EPA pursue a revision to this standard.

E. Picloram

Recent EPA occurrence analyses indicate picloram occurrence in public water systems based on a sampling of 16 States (USEPA, 2003b). Based on these analyses, EPA estimates indicate zero (number and percent) water systems within these States may have a system mean concentration exceeding the threshold of 0.5 mg/L, the current MCL for picloram. Additional occurrence estimates may be found in the above-cited 2003 EPA report.

The current BAT for picloram removal is GAC treatment. Treatment technologies were discussed by EPA in its technical support documentation (USEPA, 1990b; 55 FR 30370 at

30416, July 25, 1990 (USEPA, 1990d), 57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). Small systems compliance technologies are GAC, PAC, and POU-GAC (USEPA, 1998b).

If treatment were to require upgrading, additional GAC contact units may be added or POU treatment installed. Given available information on treatment efficacy and on occurrence levels, the Agency's current assessment is that treatment technology would not pose a limitation should EPA pursue a revision to this standard.

The current BATs and small system compliance technologies for picloram also apply to other contaminants. These treatment technologies have other beneficial effects (e.g., reduction of organics or other common impurities) in addition to picloram removal. If EPA were to consider a higher MCL, the Agency does not know how many public water systems currently treating to comply with the current MCL of 0.5 mg/L would be likely to discontinue any treatment that is already in place.

III. Treatment Review for Chemical Contaminants Regulated by Treatment Technique (TT) Requirements

This section contains a brief review of required treatment technologies for those contaminants with TT-based NPDWRs, including acrylamide, epichlorohydrin, and the Lead and Copper Rule (LCR).

As allowed under SDWA, in cases where EPA determines it is not technically or economically feasible to establish an MCL, the Agency can instead specify a TT rule. TT rules established treatment methods to minimize the level of a contaminant in drinking water.

A. Acrylamide and Epichlorohydrin

EPA regulations for acrylamide and epichlorohydrin, including polymer addition practices, were discussed in *Federal Register* notices of 1989 and 1991 (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). EPA has no new information that suggests it is appropriate to revise the TT requirements for acrylamide and epichlorohydrin at this time.

B. Lead and Copper Rule

The LCR requires the mitigation of lead and copper in public drinking water supplies through treatments, mainly through optimizing corrosion control treatment and through related monitoring strategies (56 FR 26460, June 7, 1991 (USEPA, 1991b)).

The LCR establishes treatment-type measures to control levels of lead and copper in public drinking water, including corrosion control treatment requirements for small, medium, and large water systems. Treatment may be triggered following sampling and analysis of tap water, if the value at the 90th percentile of all lead or copper samples is higher than the lead or copper action levels of 0.015 mg/L or 1.3 mg/L, respectively.

Under the LCR, public water systems that are required to conduct corrosion control studies must evaluate the effectiveness of each of the following treatments and, if appropriate, combinations of the following treatment:

- Alkalinity and pH adjustment;
- Calcium hardness adjustment; and
- Addition of a phosphate or silicate based corrosion inhibitor.

Public water systems are also required to monitor for lead and copper, and the following water quality parameters, before and after evaluating the above treatments: pH, alkalinity, calcium, conductivity, orthophosphate or silicate (where added), and water temperature. Water systems must identify constraints that limit or prohibit the use of a particular corrosion control treatment(s), and evaluate effect(s) of corrosion control chemicals on other water quality treatment processes. On the basis of the above, a public water system recommends the treatment option best suited for its system, and the State review agency considers the public water system information, and then designates optimal treatment for that system.

EPA has no information that suggests it is appropriate to revise the current TT requirements for lead and copper. However, EPA received public comments on the Agency's preliminary decisions, published in the April 17, 2002, *Federal Register*, which indicate that there is an interest in examining treatment and other aspects of the LCR (67 FR 19030 (USEPA, 2002a)). The Agency recognizes that there are challenging aspects to this rule, and that more research would be useful to obtain additional information that could be utilized to address some of the issues associated with implementation of the LCR.

Because no new data are available to make a revise/not revise determination, EPA has decided to place *lead* in the "data gaps" category, indicating that research may need to be completed prior to making further determinations. *Copper* has been placed in another category, because an EPA copper health effects assessment is underway and must be completed before EPA can determine if a revision to the NPDWR is warranted. Nonetheless, some of the potential research that is indicated below could affect the control of both copper and lead.

EPA believes that research on treatment aspects of the LCR, (*i.e.*, on effective corrosion control measures), and on other pertinent issues affecting implementation, may be appropriate. The following list represents the Agency's current understanding of general needs that may be filled by research to better inform future reviews of the NPDWR:

- Investigation of effects related to compliance with the LCR and the requirements related to disinfectants and disinfection byproducts.
- Investigation of corrosion control chemicals, including optimization and use of chemicals, constraints related to distribution system materials, possible secondary effects, and alternative approaches to current corrosion control strategies.
- Other needs including: investigation of optimization of corrosion control at systems with high alkalinity and/or hardness in source water; monitoring (e.g., targeted monitoring to represent copper levels); and small systems LCR treatment compliance issues, that may be of considerable interest.

The above represents a current synopsis of the most critical research areas related to the LCR. It is not intended to be all-inclusive nor a static listing of subject areas. The February 2002 draft version of this report included a longer listing. The above combines some of the issues and adds others. EPA believes that the above-listed items would take variable periods of time to complete, and would most likely be done in steps. In addition, they may be handled by more than one party, depending on interests and relative priorities, available funding, and other critical factors. Determining the most effective use of resources and the exact nature of research would require additional study/discussion.

EPA includes priority research within its multi-year planning process, and in its comprehensive drinking water research strategy. These help EPA prioritize and plan future research and help the Agency track current efforts. The Agency reviews plans periodically and changes them as necessary. In addition, EPA expects to further explore LCR-related research needs within the Agency, and with interested stakeholders, to inform future Agency decisions.

IV. Chemical Contaminants With MCLs Limited by Analytical Feasibility

This section includes a brief treatment technology assessment of chemicals currently regulated at MCL values that were based on analytical feasibility. More recent EPA assessments of analytical feasibility indicate the potential for lower practical quantitative levels (PQLs) for these contaminants (USEPA, 2003c).

For *all* contaminants discussed in this section, the Agency's current assessment is that treatment technology would not pose a limitation should EPA pursue a revision to any of the referenced standards. Chemical occurrence is not referenced for these contaminants, since the known occurrence levels for these (USEPA, 2003b) would not pose an obstacle to specification of treatments. Likewise, MCL values for these contaminants are not referenced.

A. Volatile Organic Contaminants

1. Benzene, Carbon Tetrachloride, 1, 2-dichloroethane, and Trichloroethylene

Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for benzene; carbon tetrachloride; 1, 2-dichloroethane; and trichloroethylene, EPA has reviewed treatment feasibility for these contaminants to determine if it is likely to become an issue if EPA were to revise any of their MCLs. The BATs for each of these contaminants are packed tower aeration (PTA) and GAC (56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). Small system compliance technologies for each include: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC (USEPA, 1998b).

The Agency discussed treatment for volatile organic chemicals (VOCs) in the 1985 proposed VOC regulation (50 FR 46902 at 46909, November 13, 1985 (USEPA, 1985a)). Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, and the Agency considers 99 percent reduction to be achievable under all anticipated conditions. In addition, in the above-cited proposed rule, EPA discussed GAC treatment for VOCs, and considers 99 percent removal to be achievable under all anticipated conditions. Thus, treatment is not known to be a limiting concern for any of the current MCLs for these four contaminants: benzene; carbon tetrachloride; 1, 2-dichloroethane; and trichloroethylene. Based

on this information, EPA's current assessment is that treatment technology would not pose a limitation, should the Agency consider revising any of their current MCLs.

2. 1,2-Dibromo-3-chloropropane (DBCP)

Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for DBCP, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. BATs include aeration and GAC (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)), and compliance technologies for small systems include GAC, PAC, and POU-GAC (USEPA, 1998b). Treatment is not known to be a limiting concern for the current MCL.

Since the Henry's coefficient for this contaminant is relatively low (*i.e.*, 7 atmospheres DBCP, which is considered "less strippable" than other contaminants), GAC may in some cases be the preferred treatment. Based on this information, EPA's current assessment is that treatment technology would not pose a limitation should the Agency consider revising the current MCL.

3. Dichloromethane (Methylene Chloride)

Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for dichloromethane, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. As a VOC, the BAT for dichloromethane is PTA (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). Small system compliance technologies include: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC (USEPA, 1998b). Treatment is not known to be a limiting concern for the current MCL.

The Agency discussed treatment for VOCs in the 1985 proposed VOC regulation (50 FR 46902 at 46909, November 13, 1985 (USEPA, 1985a)). Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, and the Agency considers 99 percent reduction to be achievable under all anticipated conditions. Based on this information, EPA's current assessment is that treatment technology would not pose a limitation, should the Agency consider revising the current MCL.

4. 1,2-Dichloropropane

Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for 1,2-dichloropropane, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. BATs for 1,2-dichloropropane includes both PTA and GAC (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). Small system compliance technologies include: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC (USEPA, 1998b). Treatment is not known to be a limiting concern for the current MCL.

Among volatile contaminants, this contaminant exhibits "average strippability" (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989)). The Agency discussed treatment for VOCs in the 1985 proposed VOC regulation (50 FR 46902 at 46909, November 13, 1985 (USEPA, 1985a)). Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by

aeration technology, and the Agency considers 99 percent reduction to be achievable under all anticipated conditions. Based on this information, EPA's current assessment is that treatment technology would not pose a limitation, should the Agency consider revising the current MCL.

5. Tetrachloroethylene ("Perc")

Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for tetrachloroethylene, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. BATs for tetrachloroethylene include PTA and GAC (56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)), and small systems compliance technologies include: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC (USEPA, 1998b). Treatment is not known to be a limiting concern for the current MCL.

The high level of volatility of tetrachloroethylene is reflected in this chemical's Henry's Law Coefficient of 214.0 atmospheres. Design of air stripping equipment was discussed in the proposal for this NPDWR. Several factors which affect engineering design include: air-to-water ratio; packed material height; available area for mass transfer; water and air temperature; and physical chemistry of the contaminant (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989)). Tetrachloroethylene, while volatile, is also highly amenable to GAC adsorption treatment. Carbon use rates for this contaminant are relatively low.

The Agency discussed treatment for VOCs in the 1985 proposed VOC regulation (50 FR 46902 at 46909, November 30, 1985 (USEPA, 1985a)). Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, and the Agency considers 99 percent reduction to be achievable under all anticipated conditions. Based on this information, EPA's current assessment is that treatment technology would not pose a limitation, should the Agency consider revising the current MCL.

B. Other Contaminants

1. Chlordane

The BAT for chlordane is GAC (56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). Treatment is not known to be a limiting concern for the current MCL. However, since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for chlordane, EPA has reviewed treatment feasibility. Chlordane is a moderately adsorbed pesticide (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). Therefore, EPA's current assessment is that treatment technology is not anticipated to pose a limitation, should the Agency consider revising the current MCL.

2. Heptachlor

The BAT for heptachlor is GAC (56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)), and small systems compliance technologies include: GAC, POU-GAC, and PAC (USEPA, 1998b). Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for heptachlor, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

Heptachlor is a moderately adsorbed organic contaminant (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). EPA's preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

3. Heptachlor Epoxide

The BAT for heptachlor epoxide is GAC (56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)), and compliance technologies for small systems include GAC, PAC, and POU-GAC (USEPA, 1998b). Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for heptachlor epoxide, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

Heptachlor epoxide is a strongly adsorbed organic contaminant, generally attributed to a low carbon usage rate (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). Based on this information, EPA's current assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

4. Hexachlorobenzene

The BAT for hexachlorobenzene is GAC (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)), and compliance technologies for small systems include GAC, PAC, and POU-GAC (USEPA, 1998b). Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for hexachlorobenzene, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

Since hexachlorobenzene is a moderately adsorbed contaminant, EPA's current assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

5. Thallium

BATs for thallium include activated alumina and ion exchange (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). EPA also listed small systems compliance technologies for this contaminant as activated alumina, ion exchange, POU-ion exchange (USEPA, 1998b). Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for thallium, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

According to technical information provided previously by EPA for thallium, competing ions in water may affect treatment run lengths (USEPA, 1998b). Assuming reasonable engineering practices, high removals of this contaminant are feasible. Removals may be expected to be greater than 90 percent using cation exchange systems, and greater than 95 percent using activated alumina treatment (55 FR 30370 at 30416, July 25, 1990 (USEPA, 1990d)). Based on this information, EPA's current assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

6. Toxaphene

The BAT for toxaphene is GAC (56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)), and small systems compliance technologies include: GAC, POU-GAC, and PAC (USEPA, 1998b). Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for toxaphene, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

According to technical information provided with the final NPDWR for toxaphene, this compound is among those that are moderately to well-adsorbed, exhibiting a relatively low carbon usage rate (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); 56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a)). Assuming reasonable engineering practices, high removals of this contaminant are feasible. Based on the above information, EPA's current assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

7. 1,1,2-Trichloroethane

BATs for 1,1,2-trichloroethane includes both PTA and GAC (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). Small systems compliance technologies for this contaminant include: PTA; diffused aeration; multi-stage bubble aerators; tray aeration; shallow tray aeration; and GAC (USEPA, 1998b). Since the results of the analytical methods feasibility review indicate that it may be possible to recalculate the PQL for 1,1,2-trichloroethane, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

According to technical information provided by EPA within the final NPDWR for 1,1,2-trichloroethane, this compound is among those moderately adsorbed chemicals, exhibiting a moderate carbon usage rate (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). 1,1,2-Trichloroethane may be among the less volatile organic chemicals (55 FR 30370 at 30416, July 25, 1990 (USEPA, 1990d)). Assuming reasonable engineering practices, treatment for removal of this contaminant is feasible. Based on this information, EPA's current assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

V. Contaminant for Which BAT Is Not Clear or Is Incorrectly Specified

BATs for cyanide include ion exchange, reverse osmosis, and "chlorine" treatment (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). CFR §141.62 and §142.62 contain erroneous BAT designations for cyanide. These will need to be revised to read "alkaline chlorination" in place of "chlorine" as a BAT for cyanide. EPA will publish a *Federal Register* notice to make the appropriate corrections to the cyanide regulation.

EPA discussed chlorination in the proposed and final regulations for cyanide (55 FR 30370 at 30416, July 25, 1990 (USEPA, 1990d); 57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). The Agency discussed the effectiveness of oxidation of cyanide at high pH in the related

technology support document (USEPA, 1990c). Thus, the Agency had technically described the correct treatment (*i.e.*, the use of chlorination at elevated pH conditions) but had an error in the published listings of BATs.

In addition, since this standard was promulgated, EPA distributed a "Public Water System Warning" (USEPA, 1994) through its regional offices. This warning included information on the use of chlorination (non-alkaline) and the potential for formation of harmful cyanogen chloride, due to reaction of chlorine with cyanide in water under those conditions. This warning also states, "EPA will change the regulations specifying BAT for removing cyanide from chlorination to alkaline chlorination."

Alkaline chlorination, through use of excess chlorine at pH values greater than 8.5, oxidizes cyanide to harmless bicarbonate and nitrogen gas. The higher the pH, the faster this reaction proceeds. The "Public Water System Warning" explains this process in detail and outlines treatment practice, including contact times, required chlorine concentrations, and compensation for temperature effects.

VI. Contaminant for Which Public Comments on EPA's Review Provided New Information

The MCL for antimony is 6 micrograms per liter ($\mu\text{g/L}$). EPA discussed BATs for antimony (*i.e.*, coagulation/filtration and reverse osmosis) in the proposed and final regulations for this contaminant (55 FR 30370 at 30416, July 25, 1990 (USEPA, 1990d); 57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992)). Small systems compliance technologies for antimony include reverse osmosis and coagulation/filtration, and POU-reverse osmosis (USEPA, 1998b).

Prior to promulgating this regulation, EPA conducted laboratory tests to determine treatment removal efficiencies on source water that had been spiked with antimony to a relatively high level, approximately 100 $\mu\text{g/L}$.

Following publication of the April 17, 2002, *Federal Register* notice with the preliminary Six-Year Review findings (67 FR 19030 (USEPA, 2002a)), the Agency received several comments from parties in Utah which indicated a difficulty in implementing the antimony standard. A few small systems have levels of antimony in their source water at or above the MCL value of 6 $\mu\text{g/L}$ (*i.e.*, at levels between 6 and 19 $\mu\text{g/L}$).

Some of these systems have been investigating treatment options for the removal of antimony from their source water. Commenters submitted supporting data documenting the results of their testing and cost analyses. According to commenters, on-site testing indicated that the designated BATs (*i.e.*, reverse osmosis and coagulation/filtration) and most of the other tested treatments were ineffective and/or prohibitively expensive due to: raw water quality concerns; water conservation needs; current costs for water production; and other concerns, such as waste water management. In addition, commenters indicated that coagulation/filtration assisted by microfiltration was unsuccessful in the removal of antimony to the MCL. These commenters noted other concerns that included: the handling of treatment chemicals, safety, and pretreatment of water. Commenters also pointed to the marked difference between the ambient water levels, at their systems, and the value at which EPA had tested the BATs.

Commenters also indicated that one technology that they tested, GFH, was very promising for antimony removal, in regard to its efficiency and operational parameters. Relative cost evaluations were also conducted. Cost analyses for the Salt Lake County Service Area No. 3 site in Snowbird, Utah, indicated that GFH may be the lowest-cost treatment option, at a total annualized (capital and operations and maintenance included) cost of \$1.80/kgal, compared to approximately \$3.90/kgal for reverse osmosis treatment. In addition to the cost issue, commenters said that reverse osmosis presented waste disposal problems and was not an acceptable option due to the volume of wasted water.

EPA believes that, should a decision be made to revise this standard (*i.e.*, to a lower level), or if the Agency determined that the occurrence of this contaminant is more widespread than currently believed, there may be a need for further research on antimony treatment removal technologies. Results of research may be useful for expanding the technology information base for this NPDWR. (Note that EPA is prohibited from making revisions to an MCL based on feasibility unless such changes maintain or provide for greater health protection.) The scope and priority of research for antimony treatment has yet to be determined by EPA. The level of priority will be better understood when the Agency has completed an assessment of the antimony health risk information.

VII. Contaminants for Which Additional Health Assessments Were Completed in 2002 or Were Anticipated in 2003

This section includes a brief treatment technology assessment of regulated chemicals for which health assessments were recently completed or were possibly going to be completed prior to, or soon after the close of the 1996 - 2002 Six-Year Review. These contaminants include, 1,1-dichloroethylene, lindane, toluene, and xylene.

A. 1,1-Dichloroethylene

The current MCL for 1,1-dichloroethylene is 0.007 mg/L. BATs and small system compliance technologies for 1,1-dichloroethylene include aeration and GAC (56 FR 3526 at 3552, January 30, 1991 (USEPA, 1991a); USEPA, 1998b). These treatment technologies also apply to other contaminants and have other beneficial effects (e.g., removal or reduction of other organics and other common impurities), in addition to removal of 1,1-dichloroethylene from water. Therefore, if EPA were to raise the MCLG/MCL, the Agency believes that few, if any, public water systems currently treating to comply with the current MCL would be likely to discontinue any such treatment that is already in place (USEPA, 2002d).

B. Lindane

The current MCL for this contaminant is 0.0002 mg/L. BAT and small system compliance technology for lindane is GAC (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992); USEPA, 1998b). This treatment technology also applies to removal or reduction of other contaminants and has other beneficial effects (e.g., removal or reduction of other organics and other common impurities), in addition to removal of lindane in water. Therefore, if EPA were to raise the MCLG/MCL, the Agency believes that few, if any, public water systems currently treating to comply with the current MCL would be likely to discontinue any such treatment that is already in place (USEPA, 2002d).

C. Toluene

The current MCL for toluene is 1 mg/L. The current BATs and small system compliance technologies for toluene include several forms of aeration and GAC (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992); USEPA, 1998b).

Field studies performed in three States using PTA demonstrated a removal efficiency of greater than 96 percent for toluene, with initial concentrations of up to 0.6 mg/L (Ram *et al.*, 1990 as cited in USEPA, 1998b). Performance studies employing diffused aeration, which is another air stripping technology used to treat toluene, have demonstrated 50 to 90 percent removal efficiencies. The study noted higher removals for VOCs that had higher Henry's Law coefficients (USEPA, 1985b as cited in USEPA, 1998a).

GAC may also be an effective treatment option for toluene, although based on cost estimates (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989)), it may be more than twice as expensive as PTA for large systems on a dollar per household per year basis. If off-gas control of PTA is necessary, costs between PTA and GAC are more competitive, but PTA is still likely to be more cost-effective for system sizes up to 1 to 10 million gallons per day (Adams and Clark, 1991). Specific cost information for GAC and PTA control of toluene is available (Adams *et al.*, 1989; Adams and Clark, 1991). Based on this information, EPA does not anticipate that treatment would pose a limitation should the Agency consider revising the current standard(s) for toluene.

D. Xylenes

The current MCL for total xylenes is 10 mg/L. The current BATs and small system compliance technologies for xylenes include several forms of aeration and GAC (57 FR 31776 at 31809, July 17, 1992 (USEPA, 1992); USEPA, 1998b).

Field studies performed in three States using PTA demonstrated a removal efficiency of greater than 96 percent for toluene, with initial concentrations of up to 0.6 mg/L (Ram *et al.*, 1990 as cited in USEPA, 1998b). Although no specific efficiency of removal by PTA was available, xylenes have larger Henry's Law coefficients (0.22 to 0.32 atmosphere-m³/mole), as compared to a coefficient of 0.0066 for toluene, and so would likely be removed at least as effectively as toluene by PTA or other air stripping technologies (HSDB, 2002; 54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989); USEPA, 2002b).

Performance studies employing diffused aeration, which is another air stripping technology like PTA, to treat xylenes have demonstrated 50 to 90 percent removal efficiencies. The study noted higher removals for VOCs that had higher Henry's Law coefficients (USEPA, 1985b as cited in USEPA, 1998a).

GAC may also be an effective treatment option for xylenes, although based on cost estimates (54 FR 22062 at 22105, May 22, 1989 (USEPA, 1989)) it may be more than twice as expensive as PTA for large systems on a cost per household basis. If off-gas control of PTA is necessary, costs between PTA and GAC are more competitive, but PTA is still likely to be more cost-effective for system sizes up to 1 to 10 million gallons per day (Adams and Clark, 1991). Specific cost information for GAC and PTA control of xylenes is available (Adams *et al.*, 1989; Adams and Clark, 1991). Based on this information, EPA does not anticipate that treatment would pose a limitation, should the Agency consider revising the current standard for xylenes.

VIII. Summary of Potential Research Needs Related to Treatment Feasibility

This report contains a number of suggestions for potential research that may be pursued by EPA or by others. It incorporates information discussed in the February 2002 draft of this report and material submitted by reviewers and commenters.

This section summarizes the potential research areas identified within the report. This is meant to be informative to the public. It does not, however, presume a relative ranking among them, and it is not to be considered a "static" listing, as it will be subject to further discussion and change. Please note that EPA and stakeholder priorities on the drinking water regulatory agenda will likely evolve; current budgets may not reflect future conditions; and, other factors will likely impact the nature of this listing over time.

EPA is using this list as the starting point in terms of identifying research and planning for research over long periods of time, including as information for the Agency's Comprehensive Drinking Water Research Strategy and for other internal Agency planning tools.

Below is a listing of areas identified during the course of the Six-Year Review as potential areas of treatment-related research. This list does not include potential research areas related to *other* technical areas, such as NPDWR contaminant occurrence, analytical methods, sampling requirements, or other matters which may be discussed in other EPA support documents.

- Investigation of treatment and water quality effects related to compliance with the LCR and requirements under the disinfectants and disinfection byproducts NPDWRs.
- Investigation of corrosion control chemicals, including optimization and use of chemicals; constraints related to distribution system materials; secondary effects; and, alternative approaches.
- Investigation of optimization of corrosion control at systems with high alkalinity and/or hardness in source water; monitoring such as targeted monitoring to represent copper levels; and small systems LCR issues.
- Efficacy of treatment technologies in removal of specific contaminants, such as antimony, chromium, and/or fluoride in drinking water. Specific needs may include investigation of operational factors, waste disposal issues, treatment effectiveness, source water quality effects, co-treatment effects, interferences from other contaminants, secondary effects related to other NPDWRs, and POU and POE applications.
- Oxidation and/or reduction effects on chromium species in water (*EPA research is underway*).

The following is not a *treatment-related* research area; it has been identified by EPA as a chemistry research need which may be of interest in relation to the common practice of drinking water fluoridation:

- The kinetics and equilibria of chemical silicofluorides used in water fluoridation treatment (*EPA research is underway*).

IX. References

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