BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	PCB AS 2021-008
PETITION OF AMEREN ENERGY	)	(Adjusted Standard – Land)
MEDIAN VALLEY COGEN LLC (OLD	)	
MEREDOSIA) FOR AN ADJUSTED	)	
STANDARD FROM 35 ADMIN. CODE	)	
PART 845	)	

NOTICE OF FILING

To: See attached Service List

PLEASE TAKE NOTICE that I have today electronically filed with the Office of the Clerk of the Pollution Control Board Ameren Energy Median Valley Cogen LLC's Motion for a 180-Day Stay, a copy of which is herewith served upon you.

Dated: December 19, 2024

AMEREN ENERGY MEDINA VALLEY
COGEN, LLC

By: ___/s/Kristen L. Gale__________

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CERTIFICATE OF SERVICE

The undersigned, an attorney, certifies that a true copy of the foregoing Notice of Filing and Ameren Energy Median Valley Cogen LLC's Motion for a 180-Day Stay was electronically filed on December 19, 2024 with the following:

Don Brown, Clerk of the Board
Illinois Pollution Control Board
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Chicago, IL 60605
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and that copies were sent via e-mail on December 19, 2024 to the parties on the service list.

Dated: December 19, 2024 /s/Kristen L. Gale

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AMEREN ENERGY MEDIAN VALLEY COGEN LLC'S MOTION FOR A 180-DAY STAY

Pursuant to 35 Ill. Adm. Code 101.514, Ameren Energy Median Valley Cogen LLC ("Ameren") respectfully requests that the Illinois Pollution Control Board ("Board") enter an order staying this proceeding for 180 days for Ameren to conduct an evaluation of an alternative to a Part 845 closure, thus avoiding the destruction of an established ecosystem that supports sensitive species. Along with conducting the evaluation during the stay, Ameren will begin the process of developing an operating permit application pursuant to Part 845 for the Old Meredosia Pond, recognizing that it is an Inactive CCR Surface Impoundment. 35 Ill. Adm. Code 845.120.

In support of its Motion to Stay, Ameren states as follows:

I. Procedural Background

1. On February 4, 2021, the Board entered its Opinion and Order on the Final Part 845 rule, a comprehensive general rule on the operation, construction and closure of coal combustion residual ("CCR") surface impoundments. Recognizing that there were site-specific issues identified by the participants that could merit different treatment than the general CCR rule, the Board stated that an entity could file a petition for an adjusted standard to address those issues. *In the Matter of: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments: Proposed New 35 Ill. Adm. Code 845*, PCB 20-19 (Feb. 4, 2021), p. 13 ("Similarly, Ameren may

also file a petition for an Adjusted Standard from part 845."), p. 14 ("In those instances, an owner or operator may seek an adjusted standard or a variance from the Board."), p. 17 ("To address site-specific issues, an affected entity may avail itself of relief mechanisms, such as an adjusted standard or a variance), p. 97 ("As with landfills, the owner or operator of a CCR surface impoundment may petition for an adjusted standard if it believes less stringent standards are appropriate for site-specific reasons.").

2. On May 11, 2021, Ameren filed its Petition for an Adjusted Standard seeking an adjusted standard from Part 845 for the Old Meredosia Pond located at Ameren's former Meredosia facility in Morgan County, IL ("Old Meredosia Pond").

3. On May 1, 2023, Ameren filed an Amended Petition for an Adjusted Standard ("Amended Petition"). The Amended Petition attached additional information on the Old Meredosia Pond, including a 2023 report by WSP describing the extensive ecosystem that developed on the pond. ("WSP Report"). Amended Petition, Exhibit 2 – Attachment A (Amended Petition Exhibits Page 620).[1] Ameren also conducted an evaluation of the groundwater under the Old Meredosia Pond which determined that the CCR in the Old Meredosia Pond is approximately 15-feet above the groundwater, and the CCR "is not inundated by groundwater during normal or flood conditions." Amended Petition, Exhibit 2 - Attachment B (Ex. Pg. 691-692). Moreover, while certain CCR constituents, including boron, were detected slightly above the Part 845 standards, Ameren's analysis concluded there was no risk to human health or the environment. Exhibit. 3 (Ex. Pg., 1049)

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[1] The Amended Petition Exhibit pages are numbered sequentially from page 1 through page 1166. The page numbers are identified herein as "Ex. Pg. X".

4. On August 3, 2023, the Agency filed its recommendation on Ameren's Petition ("Recommendation").[2] The Agency's focus was primarily on whether Old Meredosia was a CCR surface impoundment. Illinois EPA did not provide any expert report or other evidence disputing the absence of risk or disputing the presence of the significant ecosystem that is present on the Old Meredosia Pond. Indeed, related to the significant ecosystem, the Agency acknowledged an adjusted standard from certain parts of Part 845 could be granted depending on the Board's evaluation of the "valuable natural resources" present at the Old Meredosia Pond. Agency Recommendation, ¶38.

5. On February 5, 2024, Ameren filed its response to Illinois EPA's recommendation. Following filing its response, Ameren began investigating alternatives available to manage the Old Meredosia Pond that would not disturb and destroy the valuable natural resources on its surface.

II. Valuable Natural Resources at Old Meredosia

6. The WSP Report demonstrated that the Old Meredosia Pond has a significant and established ecosystem supporting a variety of plants and animals. There is an established grove of mature native vegetation on the pond, including 10.2 acres of deciduous forest, 2.3 acres of shrubbery, 3.5 acres of grassland cover. WSP Rpt., §3.2.1 (Ex. Pg. 654). Of the 54 plant species identified, 38 are native species, and approximately eight have a relatively high floristic quality. *Id*, §3.2.1 and Table 3-2 (Ex. Pg. 654, 657-658). Moreover, the grassland cover includes a sand prairie, a rare feature in Illinois. The sand prairie has an uncommon plant community that is considered to be of higher floristic value, including sandthread lovegrass, eastern prickly pear, and spotted beebalm. *Id*, §3.2.1 (Ex. Pg. 655-656).

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[2] Notably, the Agency requested and was granted seven extensions to file its Recommendation in this matter.

7. The grove of vegetation on the Old Meredosia Pond provides a habitat for numerous wildlife species, including American goldfinches, downy woodpeckers, northern cardinals, black-capped chickadees, American robins, yellow-rumped warblers, mourning doves, tufted titmice, turkey vultures, white-tailed deer, eastern cottontails, eastern gray squirrels, Virginia opossums, raccoons, and eastern moles. *Id*, §3.2.3 (Ex. Pg. 660). WSP observed a raptor nest, a turtle nest, and numerous songbird nests throughout the area, concluding that the habitat provides "functional value to wildlife for roosting, nesting, foraging, and migratory use for both resident and nonresident bird species." *Id.*

8. The Old Meredosia Pond is also a suitable habitat for various sensitive animal species. *Id.* at § 3.2.4 (Ex. Pg. 662). WSP identified a Bald Eagle nest at the Old Meredosia Pond. *Id.*, §3.2.4.1 (Ex. Pg. 662). The Bald and Golden Eagle Protection Act protects Bald Eagles nation-wide and states it is unlawful to "take" bald or golden eagles, including their parts, nests, or eggs without a permit from the Secretary of the Interior. 16 U.S.C. § 668(a). The Old Meredosia Pond is also within one of the three Illinois regions for the Illinois Chorus Frog, a state imperiled species. WSP Rpt, §3.2.4.3 (Ex. Pg. 663). Because survey methods are not available for terrestrial habitat, the Illinois Natural History Survey states that the Illinois Chorus Frog "presence should be assumed in an area if it contains sandy soil and is within 1 mile of an occupied breeding pond."[3] Here, there are documented Illinois Chorus Frog breeding areas within one-mile of the Old Meredosia Pond, which has a sandy soil. WSP Rpt, §3.2.4.3 (Ex. Pg. 663-665). Accordingly, WSP concluded that it must be assumed that the Illinois Chorus Frog is present at Old Meredosia Pond. *Id.* Similarly, WSP found that the Old Meredosia Pond is potentially suitable habitat for various

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[3] Illinois Natural History Survey. 2017. Conservation guidance for Illinois Chorus Frog (Pseudacris illinoensis). Prepared for the Illinois Department of Natural Resources, Division of Natural Heritage., p. 9; available at https://naturalheritage.illinois.gov/content/dam/soi/en/web/naturalheritage/speciesconservation/speciesguidance/documents/icf-species-guidance-final.pdf (last visited Dec. 11, 2024).

bat species, including the endangered Indiana bat, the threatened northern long-eared bat, and the threatened tricolored bat. WSP Rpt, §3.2.4.2 (Ex. Pg. 662-663).

9. WSP concluded that because Old Meredosia Pond has not been disturbed for approximately 50 years, the Pond has "important features that have moderate to high ecological value based on the presence of an established Bald Eagle nest and suitable habitat for other sensitive species." ***Id***, §3 (Ex. Pg. 666).

10. WSP further concluded that the closure methods provided for in Part 845 (either closure by removal or installing a cap) "would result in tree and vegetation removal and disruption that would result in a net loss of ecosystem value and potential direct and indirect effects on notable species and habitats." ***Id***. In particular, the overall vegetation loss would negatively impact wildlife nesting in the area, the loss of an established Bald Eagle nest that WSP believed supported two adult Bald Eagles and two juveniles, and destroy sand prairie habitat, a unique type of habitat that is presumed to support the Illinois Chorus Frog, an imperiled species. ***Id***. (Ex. Pg. 666-667).

III. Alternative Corrective Action and Closure Procedure

11. Because of the extensive ecosystem on the Old Meredosia Pond, including a Bald Eagle's nest and the likely presence of an imperiled species, Ameren identified alternative methods to treat the groundwater flowing under the Old Meredosia Pond, while also avoiding the destruction of an established ecosystem and sensitive species' habitats. In fact, this evaluation to treat the groundwater in an effective manner while also conserving an established environment, is the very type of "site-specific issue" that was identified by the Board as appropriate for an adjusted standard. *See supra* ¶1.

12. To evaluate the alternative methods, Ameren plans to conduct a treatability study of two treatment options: an in-situ resin barrier and an in-situ boron precipitation process,

described in the attached proposal. *See* attached Exhibit A. The in-situ resin barrier is a proven treatment for boron, and Ameren has had success with similar treatment systems at its energy centers in Missouri. As demonstrated in the attached discharge monitoring report, a comparison of the influent and effluent concentration charts for boron and other constituents shows a significant reduction to below the Part 845 groundwater standards following treatment. *See* attached Exhibit B, p. 2. Indeed, USEPA has identified the in-situ resin barrier as a treatment technology that is effective at reducing boron concentrations. *See* attached Exhibits C and D. The precipitation treatment is a newer technology but has shown to be an efficient mechanism to remove boron.[4]

13. Conducting the study and evaluating the results will take 180 days. The outcome will allow Ameren to evaluate alternative treatment and closure of the Old Meredosia Pond that removes the constituents in the groundwater while also preserving the ecosystem on its surface.

14. In the interim, Ameren is beginning the process of preparing an operating permit for the Old Meredosia Pond to submit to Illinois EPA. Ameren will work with Illinois EPA on developing the information required.

IV. **Request for 180-Day Stay of Proceeding**

15. The decision to grant a motion for stay is "vested in the sound discretion of the Board." *People v. State Oil Co.,* PCB 97-103 (May 15, 2004), p. 2. The Board has used a four-factor analysis to determine whether a stay is justified (considering comity; prevention of multiplicity, vexation and harassment; the likelihood of obtaining complete relief in the foreign

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[4] X, Vu, J, Lin, Y. Shih, Y. Huang, Reclaiming Boron as Calcium Perborate Pellets from Synthetic Wastewater by Integrating Chemical Oxo-Precipitation within a Fluidized-Bed Crystallizer, ACS Sustainable Chemistry & Engineering 6(4), February 2018, https://www.researchgate.net/publication/323449044_Reclaiming_Boron_as_Calcium_Perborate_Pellets_from_Synthetic_Wastewater_by_Integrating_Chemical_Oxo-Precipitation_within_a_Fluidized-Bed_Crystallizer (last visited on December 11, 2024); Y. Shih, C. Liu, W. Lan, Y. Huang, A novel chemical oxo-precipitation process for efficient remediation of boron wastewater at room temperature, Chemosphere, V. 111 Sept. 2014, Pages 232-237. https://www.sciencedirect.com/science/article/abs/pii/S0045653514004895 (last visited December 11, 2024)

jurisdiction; and the res judicata effect of a foreign judgment in the Board proceeding). *Dynegy Midwest Generation, LLC v. Illinois EPA,* PCB24-53 (April 28, 2024) 2024 ILL. ENV LEXIS 73, *2. However, "the Board is not required to consider each of these factors in making its determination." *Id, citing Bridgestone/Firestone Off Road* Tire *Co. v. IEPA,* PCB 02-31, slip op. at 3 (Nov. 1, 2001). The Board will also stay a matter to "help to avoid the potentially unnecessary expenditure of resources by the parties and the Board." *People v. The Board of Trustees of the University of Illinois*, PCB13-25/PCB13-36 (Oct. 3, 2013), 2013 Ill. ENV LEXIS 111, *13. Further, the Board must consider any ongoing environmental harm should the stay be granted. *Id*, *citing Motor Oils Refining Co. v. IEPA,* PCB 89-116, slip op. at 2 (Aug. 31, 1989).

16. Here, a 180-day stay of this matter to conduct a treatability study is justified because it could result in an appropriate alternative treatment of the Old Meredosia Pond that would effectively treat the constituents in the groundwater without destroying the established ecosystem that includes imperiled and protected species on the surface.

17. A stay would also prevent the parties and the Board from unnecessarily expending resources by continuing the petition before a practical solution is developed. Moreover, Illinois EPA is not prejudiced by the stay. Because Illinois EPA has issued only one operating permit and one construction permit to date for a CCR surface impoundment, a stay to conduct the study for an alternative to a Part 845 closure will not interrupt or slow the Agency's progress on reviewing and issuing operating and construction permits for CCR surface impoundments. Moreover, during the stay, Ameren will begin the process of developing an operating permit application for the Old Meredosia Pond pursuant to Part 845, including working with the Agency on submission of the information.

18. A stay in this proceeding will not result in environmental harm or threats to public health. The groundwater is approximately 15-feet below the CCR in the Old Meredosia Pond, and Ameren's experts established that the CCR is not inundated with groundwater in normal and flood conditions. It is also undisputed that there are no potable wells downgradient of Old Meredosia Pond and the downgradient Illinois River is not a drinking water source. *See* Amended Petition, Ex. 3, §3.4 (Ex. Pg. 1044). Further, Ameren's experts concluded that the groundwater flowing from the Old Meredosia Pond presented no risk to the Illinois River because the constituent concentrations in the groundwater are lower than the site-specific screening concentrations that were protective of surface water. *Id*, at §4, 5 (Ex. Pg. 1047-1048). Also, the constituent concentrations in the Illinois River up and downstream of the Meredosia station were similar, further demonstrating the absence of impact on the Illinois River. *Id*.

19. Indeed, not granting the stay would likely do more environmental harm. It is undisputed the 16-acre Old Meredosia Pond contains distinct habitats, including a rare sand prairie. The habitats have a diverse plant community, including plants that have significant conservation values. Moreover, the habitats support an array of animal species, including a federally protected Bald Eagles' nest and an imperiled species presumed present. The closure requirements under Part 845 would destroy the established habitats, resulting in a "net loss of ecosystem value and potential direct and indirect effects on notable species and habitats." *See* Amended Petition, Ex. 2 – Attachment A (Ex. Pg. 666).

WHEREFORE, Ameren Energy Median Valley Cogen LLC respectfully requests that the Board grant its Motion to Stay the proceeding for 180-days. Pursuant to Section 101.514(b) of the

Board's rules, Ameren Energy Median Valley Cogen LLC will submit an update to the Board on the status of the matter at the end of the stay.

Respectfully submitted,

Ameren Energy Median Valley Cogen LLC
Petitioner,

By: /s/ Kristen L. Gale
One of its Attorneys

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EXHIBIT A

Loureiro
Engineering • Construction • EH&S • Energy
Waste • Facility Services • Laboratory

VIA E-mail

November 27, 2024

Jennifer Martin
Senior Corporate Counsel
Ameren Services Company
1901 Chouteau Avenue, MC 1310
St. Louis, MO 63103

**RE: Proposal for Sample Collection and Treatability Testing Services
Evaluation of In-Situ Remediation Technologies, Old Ash Pond, Meredosia Power Station, 800 South Washington Street, Meredosia, Illinois.**

Dear Jennifer:

In response to your request, Loureiro Engineering Associates, Inc. (hereinafter “LEA” or “Consultant”), is pleased to submit this proposal for Evaluation of In-Situ Remediation Technologies at the Old Ash Pond, Meredosia Power Station, 800 South Washington Street, Meredosia, Illinois. (site). This proposal includes the scope of work (SOW) related to soil and groundwater sampling and a treatability study to evaluate an in-situ remedial alternative for contaminants of concern (COCs) in groundwater emanating from the site.

1.0 Background

The Old Ash Pond (Pond) has an area of 17 acres, and height of 15 feet. The Pond is reported to be constructed of native materials and was capped with river dredge soil during the 1970’s. The cover material is vegetated with grass and trees. Reportedly, the ash was deposited above the seasonal high groundwater table which is approximately 20 feet below the natural ground surface. Underlying the Pond is fine to coarse sands. The groundwater moves generally to the northwest towards the Illinois River, at approximately 100 feet per year. There are no groundwater flow reversals (associated with the Illinois river level fluctuations) sustained for a sufficient period of time to cause any off-site migration.

The primary ash related inorganic that is currently detected above the Illinois Part 845 groundwater standards is boron. 35 Ill. Adm. Code 845.600. Since 2021, boron concentrations measured in monitoring wells downgradient of the Pond have fluctuated between approximately 5 and 8 milligrams per liter (mg/L), above the 2 mg/L Illinois Class I groundwater standard. Additional metals detected in groundwater (i.e., selenium, iron, and manganese) that have exceeded the Part 845 groundwater standards over the 2021 to 2023 time period are also being considered in the selection of potential in-situ remedial options to ensure they also will meet the standards. Other non-metal constituents to address in the groundwater are elevated concentrations of total dissolved solids (TDS), total organic carbon (TOC), and sulfate.

The dominant form of inorganic boron in natural waters is boric acid. Among the various technologies for boron removal from waters, the adsorption process is most commonly used for dilute solutions. Various sorbents may be used for boron removal via adsorption processes, including mesoporous silica, activated carbon, clays, fly ash, natural minerals, biological materials, nanoparticles, layered double hydroxides (LDHs), selective resins, and complexing membranes. Chemical treatment methods can also be considered for precipitation of boron as perborate salts.

The projected in-situ remedial process, for the boron and potential interferences (as described above) in groundwater associated with the Pond, would be a one or two step process using a permeable reactive barrier (PRB) system. The first step, if needed, would likely be an aeration / oxidation and / or pH adjustment step to remove select dissolved inorganics and organics which may be above the Illinois Class I groundwater standards or may impact the longevity of the second step PRB process (adsorbent or precipitation process). Prior to selection and implementation of a PRB system, laboratory treatability testing is recommended for proof-of-concept validation, and full-scale design parameters development.

2.0 Scope of Work for Treatability Testing

2.1 Project Coordination

This task includes overall project management, correspondence with Ameren and subcontractors, and refinement of the appropriate resin and test conditions, including obtaining recommended doses from vendors (e.g., amendment injection).

2.2 Treatability Testing Approach

There are two general approaches to the treatability study; an evaluation of boron adsorption and precipitation processes without any pretreatment steps, and a two-phase approach that uses a pre-treatment step to reduce potential interferences for boron adsorption on the resin or in the boron precipitation process. As described above, the potential interferences include selenium, iron, manganese, TDS, sulfate, and TOC (which were identified in previous sampling events).

Soil and groundwater used in the treatability study will be collected from two sample locations (refer to Section 2.3). LEA proposes to measure boron and sulfate from the two groundwater locations using Hach field kits prior to collecting the volume needed for the treatability study (Section 2.4). Depending on the field kit results, the total groundwater volume required for testing will be collected from one or both groundwater sample locations.

Upon receipt of soil and groundwater samples at LEA's laboratory, the soil will be composited and homogenized. If groundwater is collected from two locations, the groundwater will also be composited. Prior to setting up the treatability tests, groundwater will be submitted to Teklab, Inc. (Teklab) for baseline analysis of the following:

- Total and dissolved metals: boron, calcium, iron, manganese, magnesium, potassium, selenium, and sodium
- Alkalinity
- Chloride
- Nitrate
- Sulfate
- TOC
- TDS

Depending on the results of the baseline boron concentrations, one or both groundwater types will be used in the treatability tests (i.e., if one of the two types has low boron concentrations, the second type will be used; if the two groundwaters have similar boron concentrations, they will be composited). If the results of the baseline analyses indicate that boron concentrations in both groundwater types are not representative of historical results and are too low to obtain meaningful results from the treatability testing, (i.e., boron concentrations close to laboratory detection limits would make it difficult to ascertain the level of treatment effectiveness and / or differentiate the treatment effectiveness between treatment conditions), collecting additional groundwater samples may be warranted. LEA will discuss the baseline results with Ameren prior to setting up the treatability test conditions.

2.2.1 Boron Treatment Testing

For the boron treatment testing, there are two potential PRB approaches:

1. An in-situ resin barrier (Section 2.2.1.2). Boron adsorption on ion-specific resin is proven and well documented and is being used in the ex-situ treatment process for Rush Island and the other Ameren CCR sites.
2. An in-situ boron precipitation process (Section 2.2.1.3). A chemical oxo-precipitation process for remediation of boron under ambient temperature conditions.

Both boron removal processes will be tested with and without the pretreatment steps described in Section 2.2.1.1 below.

2.2.1.1 Pre-Treatment Testing

The initial pre-treatment phase of testing is intended to reduce dissolved constituents in the groundwater, thereby maintaining the capacity and longevity of the boron PRB (resin or precipitation process) for effective boron treatment. There are two technologies for consideration in the pre-treatment testing:

1. Aeration / oxidation. Aeration will be conducted in a series of batch reactors to simulate air sparging processes. The batch reactors will contain site soil and groundwater and will consist of aerated and non-aerated (i.e., control) test conditions. The test will be conducted in replicate batch reactors with data collection at time points of 1 hour and 10 days. Groundwater from the control and treated test conditions at each time point will be analyzed for the same parameters as in the baseline analyses (refer to Section 2.2).
2. pH adjustment. The natural pH of site groundwater is neutral. The pH adjustment test conditions will be determined following an evaluation of the baseline data. The test conditions may include one or more pH adjustments and/or time points. The same time points evaluated in the aeration tests will be conducted in the pH adjustment tests (i.e., 1 hour and 10 days).

The results from the change in groundwater concentrations of the metals and other analytes over time will be evaluated to estimate the degree and rate at which aeration and/or pH adjustment reduces the dissolved concentrations of the constituents and to address any concerns with aquifer conductivity reductions.

2.2.1.2 Resin Treatment

The boron resin will be evaluated on pre-treated groundwater (Section 2.2.1.1) and groundwater without pre-treatment to determine if potential interferences impact the resin efficiency and longevity. The evaluation will be conducted in a series of columns including a control with soil only and a resin filled column. The test results will be used to evaluate the resin capacity and longevity with and without pre-treatment. The test results will also be used to determine if there is a reduction in hydraulic conductivity over the treatment duration that could potentially create preferential flow patterns or clogging within the PRB. Site groundwater will be introduced into the columns in an upward flow direction, at a flow rate equivalent to the site groundwater velocity of 100 feet per year. The effluent from the control and treated columns will be analyzed for the same analytical parameters as listed in Section 2.2.

2.2.1.3 Boron Precipitation

Boron precipitation will be evaluated on pre-treated groundwater (Section 2.2.1.1) and groundwater without pre-treatment to determine if potential interferences impact the effectiveness of boron precipitation. A very specific chemistry is needed to change the boric acid (form of boron at most sites at neutral pH) to borate and then complex or precipitate the borate with calcium or barium salts. This chemical oxo-precipitation process (COP), which combines pretreatment with an oxidant and precipitation using metal salts, was developed for treating boron-containing water under ambient temperatures at a pH 10.

The precipitation testing will be conducted in a series of batch reactors as follows:

- Peroxide followed with calcium salts
    - pH 7

  - pH 10
- Peroxide followed with barium salts
  - pH 7
  - pH 10

2.3 Soil and Groundwater Sampling

Figure 1 below shows the site and the existing groundwater monitoring wells. The soils required for the treatability study will be collected off the Pond footprint from two new borings to be performed between existing monitoring wells APW-13 and APW-14. The borings will be drilled to approximately 4 feet below the measured groundwater level. The volumes of soil to be collected from the borings are provided in Section 2.4 of this proposal.

LEA will go to the site a day before drilling to address access, verify boring locations and collect the required groundwater sample volumes (Section 2.4) from wells APW-13 and APW-14. The following morning, LEA will escort the driller and complete the borings/soil sampling. If APW-13 and APW-14 are dry (this occurred in all 3 quarters of site-wide groundwater sampling in 2024) LEA will need to collect the groundwater from the locations of the new borings. Should sampling be completed at the new boring locations, it will be conducted using direct-push technologies and a SP19 Groundwater Sampler. Limited purging will be completed at the time of sample collection and additional filtering may be required during treatability study preparation.

<u>NOTE: utility locates will not cover LEA's work in the facility; therefore, LEA will require Ameren to clear the drilling locations prior to mobilization. If there are no utilities in the area proposed for drilling, locations can be cleared using a map. If it is suspected that utilities may exist in the work area, it is preferred that locations are cleared in person.</u>

2.4 Soil and Groundwater Requirements

Soil and groundwater requirements required for the treatability testing are summarized below. Sample requirements are summarized below.

Treatability Testing Soil and Groundwater Sample Requirements	
Soil Requirements (total)	
Volume	TOTAL - 11 lbs (approximately 6 x 16-ounce jars or equivalent). If 2 locations – 5.5 lbs each (3 x 16-ounce jars or equivalent).
Container	Glass wide mouth jars or equivalent
Collection/Preservation	Store and ship on ice
Groundwater Requirements (total)	
Volume	TOTAL - 56 L
Container	Polyethylene bottles or carboys
Collection/Preservation	Store and ship on ice

Samples should be shipped at approximately 4 degrees Celsius (°C) with a proper chain of custody and all materials double sealed to:

SHIPPING ADDRESS:
Loureiro
Attn: Laurel Crawford
112 Corporate Drive, Unit 2
Portsmouth, NH 03885
Ph: 603-778-1100

3.0 Schedule

The proposed project schedule is as follows.

Task	Time Required
Procurement of Amendments and Selection of Treatment Dosages	3 weeks (conducted concurrently with submittal of baseline samples)
Baseline Analyses	2 weeks (assumes standard 2-week turn-around-time [TAT] for laboratory analysis)
Treatment Tests	3 to 4 months
Data Review and Report	2 weeks

If you have any questions regarding this proposal, please contact me at 603-778-1100.

Sincerely,

Loureiro Engineering Associates, Inc.

Laurel Crawford

Laurel Crawford
Senior Project Manager

EXHIBIT B

Submission Confirmation

DMR Summary Info

Permit Number:

UI0000043

Form Type:

Scheduled

Facility Name:

Ameren Missouri - Rush Island Power

Report Frequency:

Monthly

Monitoring Period:

10/1/24 - 10/31/24

Due Date:

11/28/24

Final DMR

View Final DMR (/epermitting/dmr/submissionConfirmation_viewFinalDMR.action) **Revise Report**

Submission Details

Submitted By:

Austin Nieman

Submitted Date:

November 4, 2024

Violations:

No

Revised:

No

You have successfully submitted your Discharge Monitoring Report (DMR) in accordance with the Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES) permit requirements.

Electronic Filing: Received, Clerk's Office 12/19/2024

Ameren Missouri - Rush Island Power
100 Big Hollow Road
FESTUS, MO, Jefferson

State of Missouri
Department of Natural Resources
National Pollutant Discharge Elimination System (NPDES)
Discharge Monitoring Report (DMR)

St. Louis Regional Office
7545 South Lindbergh,
Suite 210
St. Louis, MO, 63125

Permit Number	Outfall Number
UI0000043	UICM
Monitoring Period	
10/1/24	10/31/24
NODI:	*****

Parameters	Reporting Requirements			Unit	Reporting Requirements		Unit
pH	6.63	*****	7.09	SU	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Minimum:6.0	*****:*****	Maximum:9.0		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Measured When Monitor							
Flow, process water	*****	*****	*****	*****	0.044	0.042	Mgal/d
Mon. Location.: Other Treatment, Process Complete	*****:*****	*****:*****	*****:*****		Daily Max.:Monitoring Required	Monthly Avg.:Monitoring Required	
Sample Type: Measured							
Frequency: Monthly							
Antimony (Sb), total recoverable	<1.0	*****	<1.0	ug/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.:Monitoring Required	*****:*****	Monthly Avg.:6.0		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							
Arsenic, total recoverable	5.2	*****	3.2	ug/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.:Monitoring Required	*****:*****	Monthly Avg.:10		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							
Barium, total recoverable	79.8	*****	54.9	ug/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.:Monitoring Required	*****:*****	Monthly Avg.:2000		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							
Boron, total recoverable	2970	*****	246.5	ug/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.:Monitoring Required	*****:*****	Monthly Avg.:2000		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							
Lead (Pb), total recoverable	<1.0	*****	<1.0	ug/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.:Monitoring Required	*****:*****	Monthly Avg.:15		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							

Molybdenum (Mo), total recoverable	27.1	*****	10.9	ug/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.**:**Monitoring Required	*****:*****	Monthly Avg.**:**Monitoring Required		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							
Selenium (Se), total recoverable	<40.0	*****	<40.0	ug/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.**:**Monitoring Required	*****:*****	Monthly Avg.**:**50		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							
Sulfate, total (as SO4)	219.0	*****	148.4	mg/L	*****	*****	*****
Mon. Location.: Other Treatment, Process Complete	Daily Max.**:**Monitoring Required	*****:*****	Monthly Avg.**:**250		*****:*****	*****:*****	
Sample Type: Grab							
Frequency: Monthly							

Comments:

Ameren Missouri - Rush Island Power
100 Big Hollow Road
FESTUS, MO, Jefferson

State of Missouri
Department of Natural Resources
National Pollutant Discharge Elimination System (NPDES)
Discharge Monitoring Report (DMR)

St. Louis Regional Office
7545 South Lindbergh,
Suite 210
St. Louis, MO, 63125

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

eSignature	Submission Date	User Phone Number
Austin Nieman	**November 4, 2024**	**(618)719-4578**

Rush Island UIC System
Monthly Compliance Report

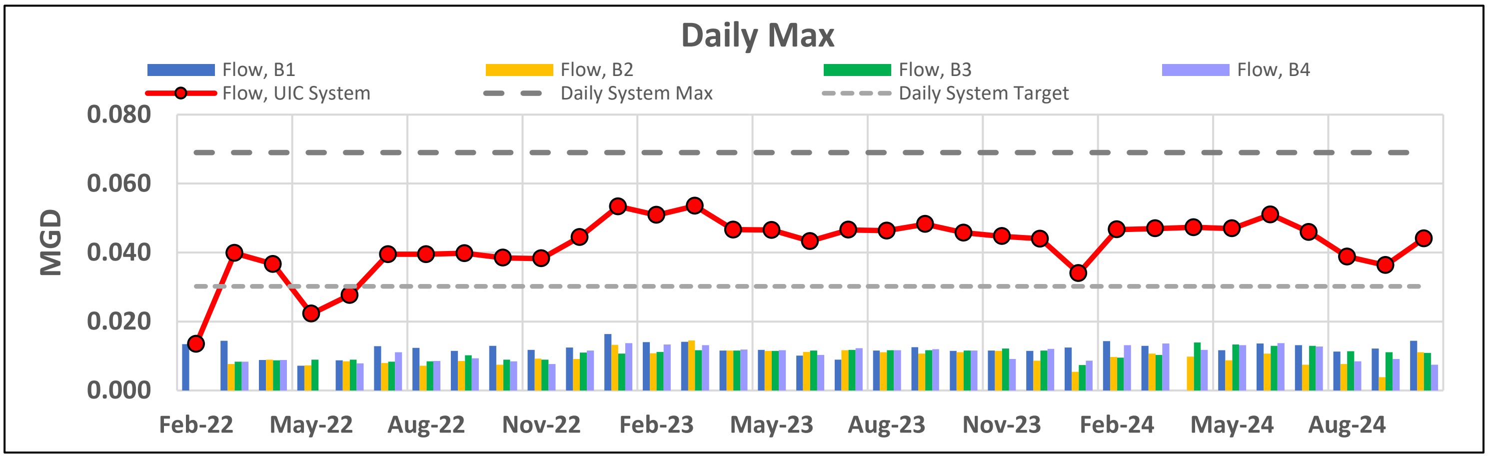
Reporting Month: **Oct-2024**

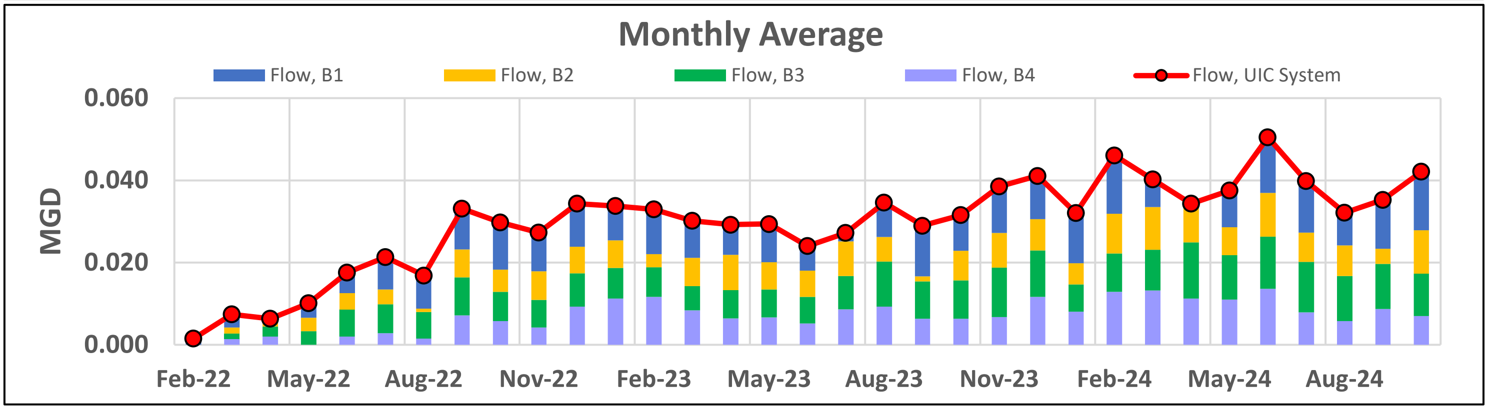
						System Reporting Requirements		
UIC Permit Parameter	**Monthly Ave Compliance**	**BLD 1 Effluent Max**	**BLD 2 Effluent Max**	**BLD 3 Effluent Max**	**BLD 4 Effluent Max**	**Daily Minimum**	**Daily Max**	**Monthly Ave Results**
pH, Field	*6.0 - 9.0*	7.09	6.92	6.68	6.63	6.63	7.09	
Flow (Mgal/day)	-	0.014	0.011	0.011	0.007		0.044	0.042
Antimony, Total (ug/L)	*6*	< 1.0	< 1.0	< 1.0	< 1.0		< 1.0	< 1.0
Arsenic, Total (ug/L)	*10*	3.4	2.5	2.3	5.2		5.2	3.2
Barium, Total (ug/L)	*2000*	23.4	70.1	66.3	79.8		79.8	54.9
Boron, Total (ug/L)	*2000*	< 20	< 40	< 20	2970		2970.0	246.5
Lead, Total (ug/L)	*15*	< 1.0	< 1.0	< 1.0	< 1.0		< 1.0	< 1.0
Molybdenum, Total (ug/L) *	*100*	6.9	7.6	27.1	< 10.0		27.1	10.9
Selenium, Total (ug/L)	*50*	< 40.0	< 40.0	< 40.0	< 40.0		< 40.0	< 40.0
Sulfate (mg/L)	*250*	185	219	89	54		219.0	148.4

* *100 mg/L is a CCR compliance goal only (UIC permit compliance for this parameter is 'monitor').*

						System Monitoring Requirements
UIC Permit Parameter (Special Condition #10)	**Notify MDNR if Exceeds**	**BLD 1 Effluent Max**	**BLD 2 Effluent Max**	**BLD 3 Effluent Max**	**BLD 4 Effluent Max**	**Effluent Max**
Beryllium, Total (ug/L)	*4*	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Lithium, Total (ug/L)	*40*	6.2	22.7	20.1	26.4	17.1
Mercury, Total (ug/L)	*2*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2

Comments:





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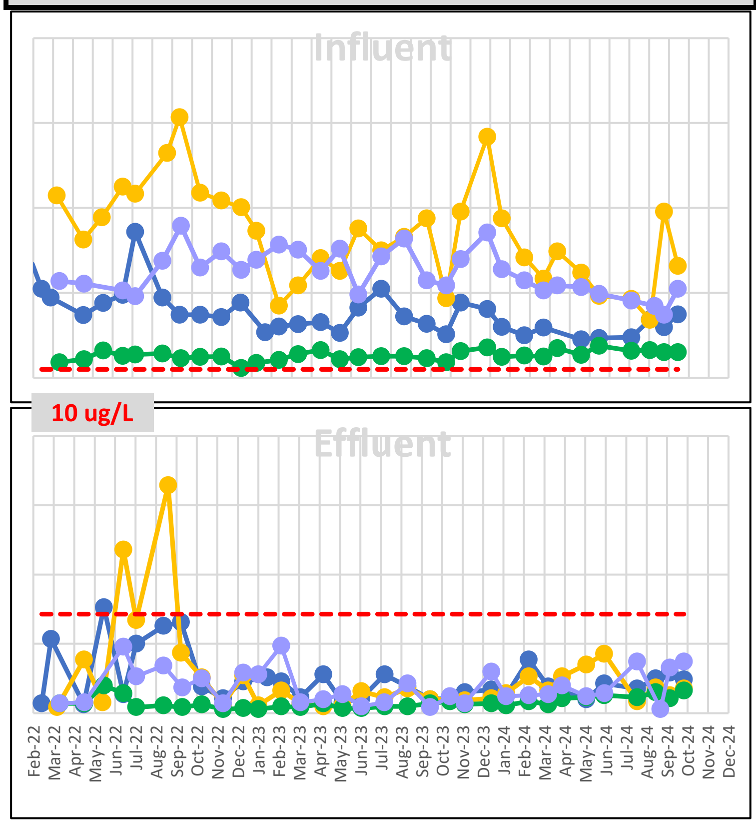

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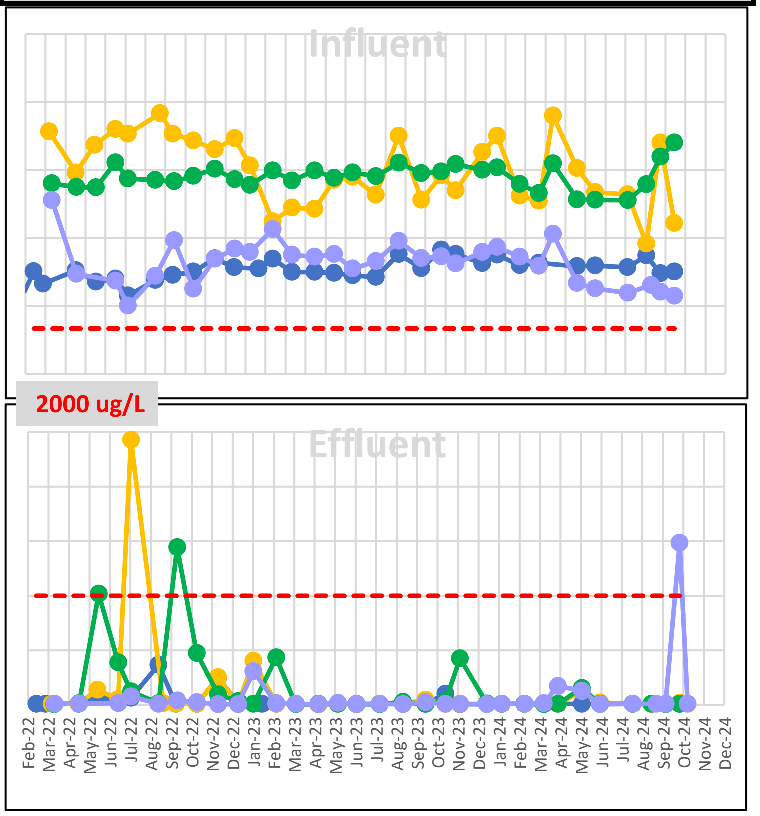

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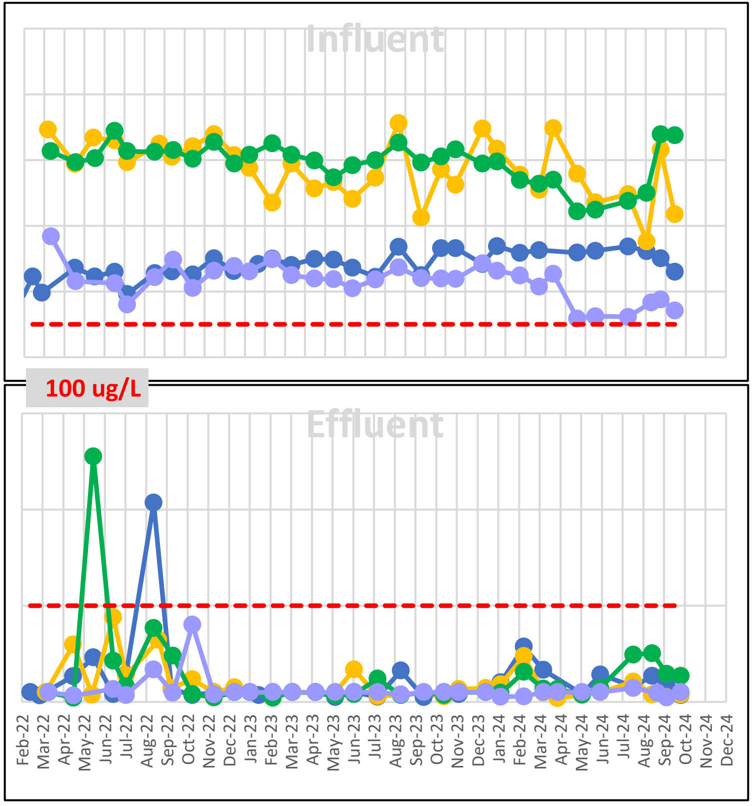

Sulfate

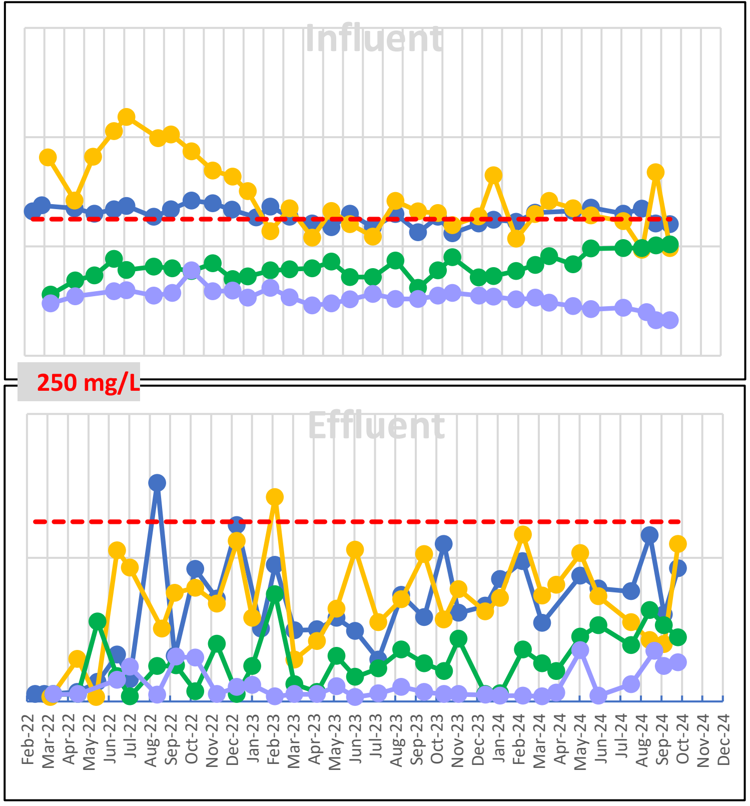

EXHIBIT C

Regulatory Determinations Support Document for Selected Contaminants from the Second Drinking Water Contaminant Candidate List (CCL 2)

Part II:

CCL 2 Contaminants Undergoing Regulatory Determination

Chapter 3:
Boron

A chapter from:

Regulatory Determinations Support Document for Selected Contaminants from the Second Drinking Water Contaminant Candidate List (CCL 2)

EPA Report 815-R-08-012

Executive Summary

Boron, an inorganic compound (IOC), is a non-volatile metalloid that is ubiquitous in the environment in compounds called borates. Common borates include boron oxide, boric acid, and borax. Anthropogenic boron compounds include boron halides (e.g., boron trichloride and boron trifluoride). Borates and other boron compounds are used in the production of glass, ceramics, soaps, fire retardants, pesticides, cosmetics, photographic materials, and high energy fuels.

Boron enters the environment mainly through the weathering of rocks, boric acid volatilization from seawater, and volcanic and geothermal activity. To a lesser extent, boron is released to the environment from anthropogenic sources (e.g., via industrial air emissions, fertilizer and herbicide applications, and industrial and municipal wastes). Limited data are available on the quantity of anthropogenic releases. Toxic Release Inventory (TRI) data suggest that air emissions dominate industrial boron trihalide releases. Boron trichloride releases fluctuate in the range of hundreds of pounds per year, and boron trifluoride releases fluctuate in the range of tens of thousands of pounds per year. Around 1990, the quantity of boron minerals used annually for agricultural purposes was estimated to have been approximately 293,000 pounds.

The Institute of Medicine of the National Academies categorizes boron as a possible trace mineral nutrient for humans. It may interact with Vitamin D and calcium homeostasis, influence estrogen metabolism, and play a role in cognitive function. The estimated average dietary intake of boron in U.S. male adults is 1.5 mg/day. Large doses (on the order of 20 mg/kg or more) can cause nausea and vomiting. Chronic low-level oral exposure causes developmental defects in animal subjects. Based on developmental defects in rats, the EPA reference dose (RfD) for boron is 0.2 mg/kg/day. EPA calculated a health reference level (HRL) of 1.4 mg/L or 1,400 µg/L for boron using the RfD of 0.2 mg/kg-day and a 20 percent screening relative source contribution (RSC). Sensitive subpopulations may include developing fetuses and individuals with impaired kidney function.

EPA evaluated boron occurrence in drinking water using data collected from 989 ground water public water systems (PWSs) by the National Inorganics and Radionuclides Survey (NIRS). The NIRS data indicate that approximately 4.3 percent of the ground water PWSs had detections of boron at levels greater than 700 µg/L (1/2 the HRL), affecting approximately 2.9 percent of the population served by these ground water systems. Approximately 1.7 percent of the ground water PWSs had detections of boron at levels greater than 1,400 µg/L (the HRL), affecting approximately 0.4 percent of the population served by these ground water systems.

Because NIRS only investigated ground water systems, the Agency evaluated the results of a survey funded by the American Water Works Association Research Foundation (AwwaRF) to gain a better understanding of the potential occurrence of boron in surface water systems. Of 341 samples analyzed for boron, approximately 67 percent represented ground water sources and 33 percent represented surface water sources. Of the ground water sources, 3.1% had boron concentrations that exceeded the HRL of 1,400 µg/L; the highest observed concentration was approximately 3,300 µg/L. In contrast, none of the surface water sources exceeded the boron HRL of 1,400 µg/L, and the highest concentration in surface water was 345 µg/L. These results indicate that boron contamination occurs less frequently and at lower concentrations in surface water than in ground water.

EPA evaluated supplementary data on boron occurrence in ambient and drinking water from additional sources, including the United States Geological Survey (USGS) National Ambient Water Quality Assessment (NAWQA) program and the Community Water System Survey (CWSS).

The Agency has made a determination not to regulate boron with a national primary drinking water regulation (NPDWR). While boron was found at levels greater than the HRL (and ½ the HRL) in several of the ground water systems surveyed by NIRS, it was not found at levels greater than the HRL (or ½ the HRL) in the surface waters sources evaluated in the AwwaRF study. Taking this surface water information into account, the Agency believes the overall occurrence and exposure from both surface and ground water systems together is likely to be lower than the values observed for the NIRS ground water data. Because boron is not likely to occur at levels of concern when considering both surface and ground water systems, the Agency believes that an NPDWR does not present a meaningful opportunity for health risk reduction.

The Agency plans to update the Health Advisory for boron to provide more recent health information. The updated Health Advisory will provide information to any States with public water systems that may have boron above the HRL. If a State finds highly localized occurrence of boron at concentrations above the HRL, it should consider whether State-level guidance (or some other type of action) may be appropriate.

The Agency's regulatory determination for this contaminant is presented formally in the *Federal Register*.

Contents

Exhibits

Abbreviations

AwwaRF	American Water Works Association Research Foundation
BMD	Benchmark Dose
CAS	Chemical Abstracts Service
CCL 2	Second Contaminant Candidate List
CWSS	Community Water Systems Survey
GW	Ground Water
HF	Hollow-Fiber
HRL	Health Reference Level
ICP	Inductively Coupled Plasma
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrometry
IOC	Inorganic Compound
IOM	Institute of Medicine
LOAEL	Lowest-Observed-Adverse-Effect Level
MDL	Method Detection Limit
MRL	Minimum Reporting Level
MTBE	Methyl Tertiary Butyl ether
NAWQA	National Water Quality Assessment
NIRS	National Inorganics and Radionuclides Survey
NOAEL	No-Observed-Adverse-Effect Level
NPDWR	National Primary Drinking Water Regulation
PTFE	Polytetrafluoroethylene
PWS	Public Water System
RfD	Reference Dose
RO	Reverse Osmosis
RSC	Relative Source Contribution
SM	Standard Method
SW	Spiral-Wound
SW	Surface Water
TRI	Toxics Release Inventory
USGS	United States Geological Survey

3 Boron

3.1 Definition

Boron, an inorganic compound (IOC), is a non-volatile metalloid that is ubiquitous in the environment in compounds called borates. Common borates include boron oxide, boric acid, and borax. Anthropogenic boron compounds include boron trichloride and boron trifluoride. The Chemical Abstracts Service (CAS) registry number of elemental boron is 7440-42-8. Borates and other boron compounds have their own registry numbers.

3.1.1 Properties and Sources

Elemental boron is not readily found in nature, yet borates are natural and ubiquitous. Elemental boron exists as a solid at room temperature, either as black monoclinic crystals or as a yellow or brown amorphous powder when impure. Boron is an essential nutrient for plants and an essential element for many organisms (USEPA, 1994a). Borates are most predominantly found in nature in oceans, sedimentary rocks, coal, shale, and some soils. Boron enters the environment mainly through the weathering of rocks, boric acid volatilization from seawater, and volcanic and geothermal activity (HSDB, 2004; ATSDR, 1992). To a lesser extent, boron is also released to the environment through anthropogenic sources. Anthropogenic boron compounds include boron halides (boron trichloride and boron trifluoride) as well as borates. Boron compounds are used in the production of glass, ceramics, soaps, fire retardants, pesticides, cosmetics, photographic materials, and high energy fuels (USGS, 2004; ATSDR, 1992). Boron compounds are registered as pesticides in the U.S. for use as insecticides, herbicides, and fungicides. In such roles, boron compounds can act in a number of ways, such as through poisoning, desiccation, or inhibition of growth (USEPA, 1994a). The production and use of products containing boron compounds adds to the release of boron into the environment. Physical and chemical properties of boron and selected boron compounds are summarized in Exhibit 3-1.

Exhibit 3-1: Physical and Chemical Properties

Identification: Boron and Boron Compounds							
	boron	***boron oxide***	***boric acid***	***borax***	***borax, anhydrous***	***boron trichloride***	***boron trifluoride***
CAS number	7440-42-8	1303-86-2	10043-35-3	1303-96-4	1303-96-4	10294-34-5	7637-07-02
Molecular Formula	B	B_2O_3	H_3BO_3	$Na_2B_4O_7 \bullet 10H_2O$	$Na_2B_4O_7$	BCl_3	BF_3
Physical and Chemical Properties							
Boiling Point	2,550 °C [1]	1,500 °C [1]	$-1^{1/2}$ H_2O, 300 °C [1]	$-10H_2O$, 320 °C [2]	Decomposes at 1,575 °C [1]	12.5 °C [2]	-99.9 °C [1]
Melting Point	2,300 °C [1]	450 ± 2 °C [1]	169 ± 1 °C tr to HBO_2 [1]	75 °C, $-8H_2O$, 60 °C [2]	741 °C [1]	-107 °C [2]	-126.8 °C [1]
Molecular Weight	10.81 /mol[2]	69.64 g/mol [2]	61.84 g/mol [2]	381.37 g/mol [1]	201.22 g/mol [1]	117.19 g/mol [2]	67.81 g/mol [2]
Log K_{oc}	-----	-----	-----	-----	-----	-----	-----
Log K_{ow}	-----	-----	-----	-----	-----	-----	-----
Water Solubility	insoluble [2]	rapidly hydrates to boric acid [1]	63.5 g/L at 30 °C [1]	20.1 g/L at 0 °C [1]	10.6 g/L at 0 °C; 87.9 g/L at 40 °C [1]	decomposes [1]	1060 g/L at 20 °C [2]
Vapor Pressure	1.56×10^{-5} atm at 2,140 °C [2]	-----	-----	-----	-----	100 mm Hg at 33.5 °C [1]	40 mm Hg at -131°C (solid); 760 mm Hg at -110.7 °C (liq) [1]
Henry's Law Constant	-----	-----	-----	-----	-----	-----	-----
Freundlich Isotherm Constant (K)	-----	-----	-----	-----	-----	-----	-----

[1] *Weast, 1988 (as cited in ATSDR, 1992 and HSDB, 2004)*
[2] *Budavari, 1989 (as cited in HSDB, 2004)*

3.1.2 Environmental Fate and Behavior

Little is known about the residence time of boron compounds in air, soil, or water. Limited data are available regarding their transport and partitioning in these media (ATSDR, 1992).

The adsorption of borates and boric acids to soils is controlled by the presence of aluminum and iron oxides and, to a lesser extent, organic matter (Bingham *et al.*, 1971; Sakata, 1987; Parks and White, 1952 all as cited in ATSDR, 1992). Soils rich in these oxides, like the Ultisols of the southeastern United States, will experience significant adsorption of available borates. In some environments, adsorption to soil particles may be irreversible (Rai *et al.*, 1986 as cited in ATSDR, 1992). Boron is found in soil (as borates) at an average concentration of 10 mg/kg (Weast, 1988 as cited in HSDB, 2004).

When released to the atmosphere, borates exist as particulate matter or aerosols, with a half-life on the order of days, depending on particle size and atmospheric conditions. Deposition can occur through dryfall, and wet deposition is also possible in the case of more soluble borates (USEPA, 1987 as cited in ATSDR, 1992).

In water, boron readily hydrolyzes and may polymerize in concentrated solutions (ATSDR, 1992). Adsorption to sediments is thought likely to be the most significant fate pathway for boron in water (Rai *et al.*, 1986 as cited in ATSDR, 1992). The extent of adsorption is determined by the pH of the water and the chemical composition of the sediment. The greatest adsorption takes place in a pH range of 7.5 to 9.0 (Keren *et al.*, 1981; Keren and Mezuman, 1981; Waggott, 1969 all as cited in ATSDR, 1992). Boron compounds in water may also co-precipitate as hydroxyborate compounds with aluminum, iron, or silicon (Biggar and Fireman, 1960 as cited in ATSDR, 1992). Boron is typically found in salt water at concentrations of 4.6 mg/L (Weast, 1988 in HSDB, 2004).

Aquatic plants and animals accumulate boron, but residues do not increase through the food chain (Moore, 1991). Even though it is found in many fruits and vegetables, boron does not accumulate in human tissues (Butterwick *et al.*, 1989 as cited in ATSDR, 1992; Waggot, 1969 as cited in ATSDR, 1992).

3.2 Health Effects

The Institute of Medicine (IOM, 2001) of the National Academies categorizes boron as a possible trace mineral nutrient for humans. Boron is essential for plant growth and deficiency studies in animals and humans have provided some evidence that low intakes of boron affects cellular function and the activity of other nutrients. It may interact with Vitamin D and calcium homeostasis, influence estrogen metabolism, and play a role in cognitive function (IOM, 2001). Iyengar *et al.* (1988, as cited in USEPA, 2004a) reported an average dietary intake of 1.5 mg/day for male adults based on the Food and Drug Administration Total Diet Study.

Some human oral data are available from cases where boron was ingested as a medical treatment. When the amount ingested was less than 3.68 mg/kg, subjects were asymptomatic, while doses of 20 and 25 mg/kg resulted in nausea and vomiting. Case reports and surveys of accidental poisonings indicate that the lethal doses of boron range from 15 to 20 grams (approximately 200 to 300 mg/kg) for adults, 5 to 6 grams (approximately 70 to 85 mg/kg) for children, and 2 to 3 grams (approximately 30 to 45 mg/kg) for infants (USEPA, 2004b).

The primary adverse effects seen in animals after chronic exposure to low doses of boron generally involve the testes and developing fetus. Chronic effects of dietary boron exposure in two-year studies included testicular atrophy and spermatogenic arrest in dogs, decreased food consumption, suppressed growth, and testicular atrophy in rats, and decreased survival, testicular atrophy, and interstitial cell hyperplasia in mice. Although researchers observed some increases in tumor incidences in the liver and in subcutaneous tissues in mice, based on comparisons to historic controls, these tumors were determined not to be associated with exposure to boron from boric acid (USEPA, 2004b). Boron is not considered mutagenic and the Agency determined that there are inadequate data to assess the human carcinogenic potential for boron (USEPA, 2004a).

In developmental studies with rats, mice, and rabbits, oral exposure to boric acid resulted in decreased pregnancy rate, increased prenatal mortality, decreased fetal weights, and increased malformations in fetuses and pups. However, these reproductive effects were associated with maternal toxicity including changes in maternal organ weights, body weights, weight gain, and increased renal tubular dilation and/or regeneration (Price *et al.*, 1990, 1994, 1996; Heindel *et al.*, 1992, 1994; Field *et al.*, 1989; all as cited in USEPA, 2004b). Reproductive effects in males were noted in the subchronic and chronic studies described in the preceding paragraphs.

The EPA reference dose (RfD) for boron is 0.2 mg/kg/day (USEPA, 2004a) based on developmental effects in rats from two studies (Price *et al.*, 1996; Heindel *et al.*, 1992; both as cited in USEPA, 2004b). The RfD was derived using the benchmark dose (BMD) method ($BMDL_{05}$ from Allen *et al.*, 1996 as cited in USEPA, 2004b). EPA calculated the health reference level (HRL) of 1.4 mg/L or 1,400 µg/L for boron using the RfD of 0.2 mg/kg/day and a 20 percent screening relative source contribution.

EPA also evaluated whether health information is available regarding the potential effects on children and other sensitive populations. Studies in rats, mice, and rabbits identify the developing fetus as potentially sensitive to boron. Price *et al.* (1996 as cited in USEPA, 2004b) identified a “lowest-observed-adverse-effect level” (LOAEL) of 13.3 mg/kg-day and a “no-observed-adverse-effect level” (NOAEL) of 9.6 mg/kg-day in the developing fetus, based on decreased fetal body weight in rats. Accordingly, boron at concentrations greater than the HRL might have an effect on prenatal development. Individuals with severely impaired kidney function might also be sensitive to boron exposure since the kidney is the most important route for excretion.

3.3 Occurrence and Exposure

3.3.1 Use and Environmental Release

The major commercial uses of boron are in the production of glass and ceramics. According to the United States Geological Survey (USGS), in 2003 these industries accounted for 78 percent of U.S. consumption of boron compounds. The industries were primarily located in the North Central United States and Eastern United States. Soaps and detergents accounted for an additional 6 percent of U.S. consumption, agriculture accounted for 4 percent, fire retardants accounted for 3 percent, and other uses accounted for 9 percent (USGS, 2004). Experimental uses include recyclable sodium borohydride fuel for powering fuel cell vehicles (USGS, 2004). Borax and boric acid are used as a neutron absorber in atomic reactors; other miscellaneous uses of borates are found in cosmetics and leather tanning (ATSDR, 1992). Boron trichloride is used in the manufacture and purification of boron, for catalysis of organic reactions, in semiconductors, in purification of metal alloys, and in bonding of iron and steels. Boron trifluoride is used predominately in catalysis, but is also used as a fumigant, in metallurgy, and for neutron detection (Windholz *et al.*, 1983).

According to the website of Rio Tinto Borax, the largest commercial producer of borates, world demand for borates is distributed among the following major uses: insulation fiberglass, textile fiberglass, and heat-resistant glass account for 42 percent of world demand; ceramic tile bodies and ceramic and enamel frits and glazes account for 14 percent; detergents, soaps, and personal care products account for approximately 10 percent; agricultural micronutrients account for 7 percent; and other uses, including wood preservatives, flame retardants, and pest control products, account for 27 percent (Rio Tinto Borax, 2004).

The United States, Turkey, and Russia are the leading producers of boron compounds, followed by Argentina, Chile, and China (USGS, 2004). In 2003, Turkey produced the greatest quantity of ore, while the U.S. led in production of refined boron compounds. U.S. boron resources, mostly sediments and brines, are primarily located in California. U.S. production of boron compounds between 1999 and 2003 ranged between 518,000 metric tons and 618,000 metric tons (measured as boric oxide). In 2003, the U.S. imported approximately 174,000 metric tons of boron compounds and exported approximately 244,000 metric tons (USGS, 2004).

Environmental boron can have natural or anthropogenic sources. Boron is a naturally occurring compound, usually found in inorganic form in sediments and sedimentary rocks. Natural weathering of rocks is thought to be the primary source of boron compounds in water and soil (Butterwick *et al.*, 1989 as cited in ATSDR, 1992). Such weathering varies geographically, however. In the United States, the richest deposits are in California. Releases to air from oceans, volcanos, and geothermal steam are other natural sources of boron in the environment (Graedel, 1978 as cited in ATSDR, 1992). Global releases of elemental boron through weathering, volcanic, and geothermal processes are estimated at approximately 360,000 metric tons annually (Moore, 1991). Human causes of boron contamination include releases to air from power plants, chemical plants, and manufacturing facilities. Fertilizers, herbicides, and industrial wastes are among the sources of soil contamination. Contamination of water can come directly from industrial wastewater and municipal sewage, as well as indirectly from air deposition and soil runoff (ATSDR, 1992). Borates in detergents, soaps, and personal care products can also contribute to the presence of boron in water.

Boric acid and its sodium salts are registered for use as pesticides. Data from the U.S. Bureau of Mines, cited in EPA's 1994 reregistration eligibility document for boron pesticides (USEPA, 1994a), suggest that approximately 293,000 pounds of boron minerals were used annually for "agricultural purposes" around 1990. In the reregistration eligibility document EPA stated that the amount of boron used specifically as pesticide is somewhat less than the amount used for agricultural purposes, and that boric acid use declined significantly during the 1980s (USEPA, 1994a).

Two anthropogenic boron compounds, boron trichloride and boron trifluoride, are listed as Toxics Release Inventory (TRI) chemicals. For a discussion of the nature and limitations of TRI data, see Chapter 2.

TRI data for boron trichloride (see Exhibit 3-2) are reported for the years 1995 to 2003 (USEPA, 2006). For boron trichloride, on-site air emissions constitute all of the total releases (on- and off-site), and these have generally fluctuated in the range of hundreds of pounds per year during the period of record. TRI releases for boron trichloride were reported from facilities in 6 States (Arizona, California, Indiana, New Mexico, Pennsylvania, and Wisconsin).

Exhibit 3-2: Environmental releases (in pounds) of boron trichloride in the United States, 1995-2003

Year	On-Site Releases				Off-Site Releases	Total On- & Off-site Releases
	Air Emissions	Surface Water Discharges[1]	Underground Injection	Releases to Land		
1995	5	-	0	0	0	5
1996	37	-	0	0	0	37
1997	754	0	0	0	0	754
1998	750	0	0	0	0	750
1999	350	-	0	0	0	350
2000	605	-	0	0	0	605
2001	626	0	0	0	0	626
2002	258	0	0	0	0	258
2003	5	-	0	0	0	5

[1] "-" denotes blank cells on reporting forms. "0" is entered when the reporting forms contained only zeros or "NA's.

Source: USEPA, 2006.

Boron trifluoride releases, also for the years 1995 to 2003 (see Exhibit 3-3), are similarly dominated by on-site air emissions. Boron trifluoride releases ranged in the tens of thousands of pounds annually. TRI releases for boron trifluoride were reported from facilities in 14 States (AL, AR, DE, FL, KY, LA, MD, NY, OH, OK, PA, SC, TN, and TX) (USEPA, 2006).

Exhibit 3-3: Environmental releases (in pounds) of boron trifluoride in the United States, 1995-2003

Year	On-Site Releases				Off-Site Releases	Total On- & Off-site Releases
	Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1995	25,019	0	0	0	929	25,948
1996	29,881	0	0	0	0	29,881
1997	21,290	0	0	0	5	21,295
1998	37,802	5	0	0	0	37,807
1999	16,725	0	0	0	0	16,725
2000	11,595	0	0	0	250	11,845
2001	11,496	0	0	0	0	11,496
2002	10,114	0	0	0	0	10,114
2003	7,513	0	0	0	4,295	11,808

Source: USEPA, 2006.

3.3.2 Ambient Water Occurrence

Ambient lakes, rivers, and aquifers are the source of most drinking water. Data on the occurrence of boron in ambient water, as well as biotic tissue and bed sediment, are available from the National Water Quality Assessment (NAWQA) program of the USGS. For more information on this program, see Chapter 2. The Minnesota Pollution Control Agency has also surveyed boron in ground water.

NAWQA

No national NAWQA data are available on the occurrence of boron in ambient waters. However, some regional data are available. Boron was among the analytes in USGS ground water monitoring in the Sacramento Valley in California in 1996 (Dawson, 2001) and the lower Illinois River Basin from 1984 to 1991 (Warner, 1999). Boron was also an analyte in NAWQA studies of bed sediments and/or fish tissues from the Tualatin River Basin of Oregon from 1992 and 1996 (Bonn, 1999), the Lower Snake River Basin of Idaho and Oregon in 1997 (Clark and Maret, 1998), and the Yellowstone River Basin in Montana, North Dakota, and Wyoming from 1976 to 1979 (Peterson and Zelt, 1999).

In ground water from the Sacramento Valley aquifer, boron was detected in all 31 samples, in concentrations ranging from 12 µg/L to 1,100 µg/L. The median concentration was 42 µg/L. Two of the 31 samples had concentrations in excess of the then-current Health Advisory Level of 600 µg/L (Dawson, 2001). (That lifetime Health Advisory Level was associated with an RfD of 0.09 mg/kg/day. In June 2004 EPA established the current RfD of 0.02 mg/kg/day.)

In the lower Illinois River Basin, 71 percent of ground water samples collected between 1984 and 1991 contained boron concentrations higher than the minimum reporting level for this study of 50 µg/L. The highest detected concentration was 2,100 µg/L. Higher boron concentrations were generally found in deeper and more ancient aquifers (Warner, 1999).

At a minimum reporting level of 0.2 µg/g dry weight, boron was detected in 100 percent of ten fish tissue samples from the Tualatin River Basin. The median concentration was 1.2 µg/g and the maximum concentration was 3.5 µg/g (Bonn, 1999).

At a minimum reporting level of 0.1 µg/g dry weight, boron was detected in most or all of 25 fish tissue samples from the Lower Snake River Basin, in concentrations as high as 1.8 µg/g (Clark and Maret, 1998).

At a reporting limit of 10 mg/kg, boron was detected in 98 percent of bed sediment samples in the Yellowstone River Basin. The median concentration was 28 mg/kg and the 95th percentile concentration was 57 mg/kg (Peterson and Zelt, 1999).

Minnesota Pollution Control Agency

As a baseline survey of ground water quality in the State, the Minnesota Pollution Control Agency took samples from 954 drinking water wells between 1992 and 1996. Seventy (8.7 percent of) samples had boron concentrations in excess of 600 µg/L, and another 25 samples had concentrations between 500 and 600 µg/L. High boron concentrations in Cretaceous, Precambrian, and buried Quaternary aquifers are likely due to the natural abundance of boron in the earth's crust. High boron concentrations in surficial Quaternary aquifers, on the other hand, are likely due to anthropogenic factors. The overall median concentration of boron was 46 µg/L (MPCA, 1998).

3.3.3 Drinking Water Occurrence

In the 1980s, EPA collected nationally representative data on boron occurrence in drinking water from public water systems served by ground water as part of the National Inorganics and Radionuclides Survey (NIRS). More recently, the American Water Works Association Research Foundation (AwwaRF) conducted a study of boron occurrence that included both ground water and surface water systems.

NIRS

Between 1984 and 1986, single samples were taken from 989 community public water systems (PWSs) under NIRS. Only systems served by ground water were included in the survey. Systems were selected to be geographically representative, and to include a representative distribution of system sizes. For more details on NIRS, see Chapter 2 and USEPA (2008).

Results of the survey are presented in Exhibit 3-4. Approximately 81.9 percent of groundwater PWSs had detections of boron (that is, concentrations at or above the minimum reporting level: ≥ MRL, or ≥ 0.005 mg/L). These detections affected about 88.1 % of the population served by the PWSs, equivalent to approximately 75.5 million people served by ground water nationally. Detections at a concentration greater then one-half the HRL (> ½ HRL, or > 0.7 mg/L) occurred in 4.3% of surveyed PWSs, affecting 2.9% of the population served, equivalent to approximately 2.5 million people nationally. Concentrations greater than the HRL (> HRL, or > 1.4 mg/L) were found in approximately 1.7% of surveyed PWSs, affecting 0.4% of the population served, equivalent to approximately 0.4 million people nationally.

Exhibit 3-4: Summary NIRS Occurrence Statistics for Boron in Ground Water Systems

Frequency Factors	**NIRS Data on Boron**		**National System & Population Numbers**[1]
Total Number of Ground Water Samples/Systems	989		59,440
99th Percentile Concentration (all samples)	2.44 mg/L		--
Health Reference Level (HRL)	1.4 mg/L		--
Minimum Reporting Level (MRL)	0.005 mg/L		--
Maximum Concentration of Detections	3.95 mg/L		--
99th Percentile Concentration of Detections	2.6 mg/L		--
Median Concentration of Detections	0.047 mg/L		--
Total Population Served by Ground Water	1,482,153		85,681,696
Occurrence by Sample/System	**Number**	**Percentage**	**National Extrapolation**
Ground Water PWSs with Detections (≥ MRL)	810	81.9%	48,682
Range of NIRS States	0 - 74	0 - 100%	N/A
Ground Water PWSs > 1/2 HRL	43	4.3%	2,584
Range of NIRS States	0 - 8	0 - 37%	N/A
Ground Water PWSs > HRL	17	1.7%	1,022
Range of NIRS States	0 - 5	0 - 26%	N/A
Occurrence by Population Served			
Population Served by GW PWSs with Detections	1,306,048	88.1%	75,501,000
Range of NIRS States	0 - 343,465	0 - 100%	N/A
Population Served by GW PWSs > 1/2 HRL	42,702	2.9%	2,469,000
Range of NIRS States	0 - 20,465	0 - 34%	N/A
Population Served by GW PWSs > HRL	6,443	0.4%	372,000
Range of NIRS States	0 - 2,500	0 - 34%	N/A

1. Total PWS and population numbers are from EPA's March 2000 Water Industry Baseline Handbook, 2nd Edition. National extrapolations are generated by multiplying the system/population percentages and the national Baseline Handbook system/population numbers.

Abbreviations:
PWS = Public Water Systems; GW = Ground Water; N/A = Not Applicable; Total Number of Samples/Systems = total number of samples/systems on record for the contaminant; 99th Percentile Concentration = the concentration in the 99th percentile sample (out of either all samples or just samples with detections); Median Concentration of Detections = the concentration in the median sample (out of samples with detections); Total Population Served = the total population served by PWSs for which sampling results are available; Ground Water PWSs with Detections, PWSs > ½ HRL, or PWSs > HRL = GW PWSs with at least one sampling result greater than or equal to the MRL, exceeding the ½ HRL benchmark, or exceeding the HRL benchmark, respectively; Population Served by GW PWSs with Detections, by PWSs > ½ HRL, or by PWSs > HRL = population served by GW PWSs with at least one sampling result greater than or equal to the MRL, exceeding the ½ HRL benchmark, or exceeding the HRL benchmark, respectively.

Notes:
-Only results at or above the MRL were reported as detections. Concentrations below the MRL are considered non-detects.

AwwaRF Boron Study

Both ground water PWSs and surface water PWSs were included in a boron survey funded by the American Water Works Research Foundation (Frey *et al.*, 2004). The AwwaRF study recruited 189 PWSs representing 407 source waters in 41 States. Of the 407 source water sample kits distributed in 2003, approximately 342 were returned. Of these 342 samples, 341 were analyzed for boron. Approximately 67 percent (or 228) represented ground water sources and 33 percent (or 113) represented surface water sources. The samples were analyzed for boron with a method detection limit of 2.0 µg/L (Frey *et al.*, 2004).

Boron was detected with concentrations equal or greater than the method detection limit in 226 of 228 ground water samples (99.1%) and 110 of 113 surface water samples (97.3%). Boron concentrations greater than ½HRL, or >0.7 mg/L, were found in 20 of 228 ground water samples (8.8%) and no surface water samples (0%). Boron concentrations greater than the HRL, or >1.4 mg/L, were found in seven of 228 ground water samples (3.1%) and no surface water samples (0%). The seven HRL exceedances were found at five systems. The highest concentration detected in ground water was approximately 3.32 mg/L, and the highest concentration in surface water was 0.345 mg/L (Seidel, 2006). The median concentrations were 0.0514 mg/L in ground water and 0.029 mg/L in surface water (Frey *et al.*, 2004).

Although the survey was not statistically representative, it indicates some general trends. On the whole, boron contamination of surface water is less significant than contamination of ground water. No geographic trends were evident in ground water results, but surface water contamination appeared to be more prevalent in the Western U.S. than the Eastern U.S. Longitudinal sampling (i.e., sampling at multiple points along the path of water undergoing treatment) at 15 systems revealed that a wide variety of treatment techniques were largely ineffective at removing boron, so boron concentrations in source water (such as those collected in this study) are likely to be indicative of concentrations in finished water (Frey *et al.*, 2004).

Community Water System Survey (CWSS)

The 2000 Community Water System Survey (CWSS) (USEPA, 2002a; 2002b) gathered data on the financial and operating characteristics of a random sample of community water systems nationwide. In addition, the Survey asked all "very large" community water systems, those that serve more than 500,000 people (a total of 83 systems), to provide monitoring results for five regulated compounds (arsenic, atrazine, 2,4-D, simazine, and glyphosate) and four unregulated compounds (radon, methyl tertiary-butyl ether [MTBE], metolachlor, and boron), including results from raw water at each intake and from finished water at each treatment plant. EPA received completed questionnaires from 58 systems. However, not all systems answered every question. Note that because reported results are incomplete, they are more illustrative than statistically representative.

Results of raw water monitoring are aggregated by type of intake. In raw ground water, 34 observations of boron occurrence were reported. Among detects, the median concentration was 120 µg/L and the 90th percentile concentration was 273 µg/L. Non-detects were reported at 2.6 percent of ground water intakes. In raw surface water, 15 observations of boron occurrence were reported. Among detects, the median concentration was 59 µg/L and the 90th percentile concentration was 180 µg/L. Non-detects were reported at 22.2 percent of surface water intakes (USEPA, 2002b).

Results of finished water monitoring are aggregated by system type. At systems primarily served by ground water, 5 observations of boron occurrence were reported. Among detects, the median concentration was 102 µg/L and the 90th percentile concentration was 234 µg/L. No non-detects were reported. At systems primarily served by surface water, 14 observations of boron occurrence were reported. Among detects, the median concentration was 56 µg/L and the 90th percentile concentration was 500 µg/L. Non-detects were reported at 9.1 percent of treatment plants. At systems primarily served by purchased water, 6 observations of boron occurrence were reported. Among detects, the median concentration was 164 µg/L and the 90th percentile concentration was 200 µg/L. Non-detects were reported at 1.8 percent of treatment plants (USEPA, 2002b).

3.4 Technology Assessment

3.4.1 Analytical Methods

Boron can be detected using EPA Method 200.7. Method 200.7 relies on inductively coupled plasma-atomic emission spectrometry (ICP-AES). A full description of EPA Method 200.7 can be found in EPA's *Methods for the Determination of Metals in Environmental Samples Supplement 1* (USEPA, 1994b). A brief summary of this method is provided below. It should be noted that the analytical result of this method is for the amount of elemental boron; the method does not identify the boron compound(s) present.

EPA Method 200.7

In EPA Method 200.7 (Revision 4.4), "*Determination of Metals and Trace Elements in Water and Wastes by ICP/Atomic Emission Spectrometry,*" an aliquot of a well-mixed, acid-preserved aqueous sample is accurately transferred for sample processing. The sample is made up to one-half the original aliquot volume, mixed, and then allowed to settle overnight if the prepared aliquot contains undissolved material. Note that in low-turbidity water, boron determinations can be completed by "direct analysis" of acid-preserved samples. The analysis involves multielemental determinations by ICP-AES using sequential or simultaneous instruments. The instruments measure characteristic atomic-line emission spectra by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by a radio-frequency ICP. The spectra are dispersed by a grating spectrometer, and the intensities of the line spectra are monitored at specific wavelengths by a photosensitive device (USEPA, 1994b).

Note that boron samples can become contaminated by borosilicate glass. Only plastic or polytetrafluoroethylene (PTFE) labware should be used when collecting, storing, and handling water samples for boron analysis (USEPA, 1994b).

The method detection limit (MDL[1]) for boron using Method 200.7 is reported to be 0.003 mg/L (USEPA, 1994b). The average recovery ranges from 97 to 98 percent depending on the spike concentration and whether tap or well water was used.

Another possible method for boron detection is Standard Method (SM) 4500-B B. The analytical range for this method is between 100 to1,000 µg/L. This method, known as the Curcumin Method, is available in the 19th edition of *Standard Methods for the Examination of Water and Wastewater* (AWWA, 1995).

3.4.2 Treatment Technologies

Treatment technologies do not influence the determination of whether or not a contaminant should be regulated. However, before a contaminant can be regulated with a national primary drinking water regulation (NPDWR), treatment technologies must be readily available. There is no evidence that boron and boron compounds are significantly removed by conventional treatments, such as coagulation/flocculation, sedimentation, and inert media filtration. Two treatment technologies that may be appropriate are ion exchange and reverse osmosis.

Ion exchange involves the selective removal of charged inorganic species from water using an ion-specific resin. The surface of the ion exchange resin contains charged functional groups that hold ionic species by electrostatic attraction. As water passes by the resin, charged ions on the resin surface are exchanged for the contaminant species in the water. When all of the resin's available exchange sites have been replaced with ions from the feed water, the resin is exhausted and must be regenerated or replaced.

Wong (1984) evaluated eight technologies for their ability to remove boron from evaporator product water at power plants. Boron concentration in the evaporator-product water averaged 11 mg/L, and ranged as high as 38 mg/L. Only three technologies successfully reduced boron levels to below 0.3 mg/L. These were a boron-specific ion exchange resin, a process of coagulation, precipitation and filtration, and a strong-base anion-exchange resin. Wong dismissed the coagulation, filtration, and filtration process as unacceptable due to high chemical dosage requirements and high operating cost. Of the two ion exchange methods, Wong determined that the strong-base anion exchange resin would have lower regeneration costs, at least in the case of the evaporator product water, which is low in dissolved solids.

Reverse osmosis (RO) is similar to other membrane processes, such as ultrafiltration and nanofiltration, in that water passes through a semi-permeable membrane. However, in the case of RO, the membrane is non-porous. RO involves the use of applied hydraulic pressure to oppose the osmotic pressure across the membrane, forcing the water from the concentrated-

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[1] The Method Detection Limit is a statistical estimate of the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, *i.e.*, greater than the background signal. The calculation of the MDL is based upon the precision of a series of replicate measurements of the analyte at low concentrations. The MDL incorporates estimates of the accuracy of the determination. The MDL is not a concentration that can typically be measured by the method on a routine basis. Detection limits may vary between analysts and laboratories under various laboratory conditions.

solution side to the dilute-solution side. The water dissolves into the membrane, diffuses across, then dissolves out into the permeate. Most inorganic and many organic contaminants are rejected by the membrane and will be retained in the concentrate.

Folster *et al.* (1980) tested hollow-fiber (HF) RO and spiral-wound (SW) RO in two separate treatment plants in New Mexico. At the treatment plant in San Jon, with influent boron levels of 0.75 mg/L, HF RO and SW RO removed 15 percent and 3 percent of boron, respectively. At Alamogordo, however, where influent concentrations were lower (0.09 mg/L), HF RO and SW RO were ineffective; in fact, boron concentrations rose to 0.14 mg/L and 0.13 mg/L, respectively. These findings suggest that the potential for RO use in boron treatment is limited.

3.5 Regulatory Determination

The Agency has made a determination not to regulate boron with a national primary drinking water regulation (NPDWR). While boron was found at levels greater than the HRL (and ½ the HRL) in several of the ground water systems surveyed by NIRS, it was not found at levels greater than the HRL (or ½ the HRL) in the surface waters sources evaluated in the AwwaRF study. Taking this surface water information into account, the Agency believes that the overall national occurrence and exposure from both surface and ground water systems together is likely to be lower than the values observed for the NIRS ground water data. Because boron is not likely to occur at levels of concern when considering both surface and ground waters systems, the Agency believes that an NPDWR does not present a meaningful opportunity for health risk reduction.

The Agency plans to update the Health Advisory for boron to provide more recent health information. The updated Health Advisory will provide information to any States with public water systems that may have boron above the HRL. If a State finds highly localized occurrence of boron at concentrations above the HRL, it should consider whether State-level guidance (or some other type of action) may be appropriate.

The Agency's regulatory determination for this contaminant is presented formally in the *Federal Register*.

3.6 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological Profile for Boron*. Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp26.html.

Allen, B.C., P.L. Strong, C.J. Price, S.A. Hubbard, and G.P. Datson. 1996. Benchmark Dose Analysis of Developmental Toxicity in Rats Exposed to Boric Acid. *Fundamental and Applied Toxicology*. 32:194-204. (As cited in EPA, 2004b.)

American Water Works Association (AWWA). 1995. *Standard Methods for the Examination of Water and Wastewater, 19th Edition.*

Biggar, J.W. and M. Fireman. 1960. Boron adsorption and release by soils. *Soil Science Society of America Proceedings*. 24:115-120. (As cited in ATSDR, 1992.)

Bingham, F.T., A.L. Page, N.T. Coleman, and K. Flach. 1971. Boron adsorption characteristics of selected amorphous soils from Mexico and Hawaii. *Soil Science Society of America Proceedings*. 35:546-550. (As cited in ATSDR, 1992.)

Bonn, B.A. 1999. *Selected Elements and Organic Chemicals in Bed Sediment and Fish Tissue of the Tualatin River Basin, Oregon, 1992-96*. U.S. Geological Survey Water-Resources Investigations Report 99-4107. 61 pp. Available on the Internet at: http://or.water.usgs.gov/pubs_dir/Pdf/99-4107.pdf.

Budavari, S. (ed.) 1989. *The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals*. Rahway, NJ: Merck and Co., Inc. (As cited in HSDB, 2004.)

Butterwick, L., N. de Oude, and K. Raymond. 1989. Safety Assessment of Boron in Aquatic and Terrestrial Environments. *Ecotoxicology and Environmental Safety*. 17:339-371. (As cited in ATSDR, 1992.)

Clark, G.M. and T.R. Maret. 1998. *Organochlorine compounds and trace elements in fish tissue and bed sediments in the lower Snake River Basin, Idaho and Oregon*. U.S. Geological Survey Water-Resources Investigations Report 98-4103. 35 pp. Available on the Internet at: http://id.water.usgs.gov/PDF/wri984103/ORGANOSX.PDF.

Dawson, B.J.M. 2001. *Ground-water quality in the southeastern Sacramento Valley aquifer, California*. U.S. Geological Survey Water-Resources Investigations Report 01-4125. 24 pp. Available on the Internet at: http://pubs.usgs.gov/wri/wri014125/wrir01-4125.pdf.

Field, E.A., C.J. Price, M.C. Marr, C.B. Myers, R.E. Morrissey, and B.A. Schwetz. 1989. *Final report on the developmental toxicity of boric acid (CAS No. 10043-35-3) in CD-1-Swiss Mice.* NTP Final Report No. 89-250. (As cited in USEPA, 2004b.)

Folster, H.G., D.B. Wilson, S. Hanson, and R. Duran. 1980. *Water Treatment for Small Public Supplies*. New Mexico Water Resources Research Institute (WRRI). WRRI Report No. 119.

Frey, M.M., C. Seidel, M. Edwards, J. Parks, and L. McNeill. 2004. *Occurrence Survey for Boron and Hexavalent Chromium.* AwwaRF Report 91044F.

Graedel, T.E. 1978. Inorganic elements, hydrides, oxides, and carbonates. In: *Chemical Compounds in the Atmosphere*. New York, NY: Academic Press, pp. 35-49. (As cited in ATSDR, 1992.)

Hazardous Substances Data Bank (HSDB). 2004. Search for boron. Available on the Internet through TOXNET, sponsored by the National Institute of Health's National Library of Medicine. Available on the Internet at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. Accessed November 1, 2004.

Heindel, J.J., C.J. Price, E.A. Field, M.C. Marr, C.B. Myers, R.E. Morrissey, and B.A. Schwetz. 1992. Developmental toxicity of boric acid in mice and rats. *Fundamental and Applied Toxicology*. 18:266-277. (As cited in USEPA, 2004b.)

Heindel, J.J., C.J. Price, and B.A. Schwetz. 1994. The developmental toxicity of boric acid in mice, rats and rabbits. *Environmental Health Perspectives Supplements*. 102(S7):107-112. (As cited in USEPA, 2004b.)

Institute of Medicine (IOM). 2001. Boron. Chapter in: *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc.* Washington, DC: National Academy Press. pp. 510-521.

Iyengar, G.V., W.B. Clarke, R.G. Downing, and J.T. Tanner. 1988. Lithium in biological and eietary materials. In: *Proceedings of the 5th International Workshop on Trace Element Analytical Chemistry in Medicine and Biology*. 5:267-269. (As cited in USEPA, 2004a.)

Keren, R. and U. Mezuman. 1981. Boron adsorption by clay minerals using a phenomenological equation. *Clays and Clay Minerals*. 29:19-204. (As cited in ATSDR, 1992.)

Keren, R., R.G. Gast, and B. Bar-Yosef. 1981. pH-dependent boron adsorption by Na-montmorillonite. *Soil Science Society of America Journal.* 45:45-48. (As cited in ATSDR, 1992.)

Moore, J.W. 1991. *Inorganic Contaminants of Surface Water: Research and Monitoring Priorities.* New York, NY: Springer-Verlag.

Minnesota Pollution Control Agency (MPCA). 1998. *Baseline Water Quality of Minnesota's Principal Aquifers*. Available on the Internet at: http://www.pca.state.mn.us/water/groundwater/gwmap/gwbaselinerpt.html. Accessed October 13, 2004. Last updated October 28, 1998.

Parks, W.L. and J.L. White. 1952. Boron retention by clay and humus systems saturated with various cations. *Soil Science Society of America Proceedings*. pp. 298-300. (As cited in ATSDR, 1992.)

Peterson, D.A. and R.B. Zelt. 1999. *Element concentrations in bed sediment of the Yellowstone River Basin, Montana, North Dakota, and Wyoming--A retrospective analysis*. U.S. Geological Survey Water-Resources Investigations Report 99-4185. 23 pp. Available on the Internet at: http://water.usgs.gov/pubs/wri/wri994185/pdf/wri994185.pdf.

Price, C.J., E.A. Field, M.C. Marr, C.B. Myers, R.E. Morrissey, and B.A. Schwetz. 1990. *Developmental Toxicity of Boric Acid (CAS No. 10043-35-3) in Sprague Dawley Rats.* NTP Report No. 90-105. (As cited in USEPA, 2004b.)

Price, C.J., M.C. Marr, and C.B. Myers. 1994. *Determination of the No-observable-adverse-effect level (NOAEL) for Developmental Toxicity in Sprague-Dawley (CD) Rats Exposed to Boric Acid in Feed on Gestational Days 0 to 20, and Dvaluation of Postnatal Recovery through Postnatal Day 21*. Final report. (As cited in USEPA, 2004b.)

Price, C.J., P.L. Strong, M.C. Marr, C.B. Myers, and F.J. Murray. 1996. Developmental toxicity NOAEL and postnatal recovery in rats fed boric acid during gestation. *Fundamental and Applied Toxicology*. 32:179-193. (As cited in USEPA, 2004b.)

Rai, D., J.M. Zachara, A.P. Schwab, R. Schmidt, D. Girvin, and D. Rogers. 1986. Chemical attenuation rates, coefficients, and constants in leachate migration. Vol. 1. A critical review. Report to Electric Power Research Institute, Palo Alto, CA by Battelle, Pacific Northwest Laboratories, Richland, WA. Research Project 2198-1. (As cited in ATSDR, 1992.)

Rio Tinto Borax. 2004. Rio Tinto Borax 2003 Report on Sustainability: Company Overview, Borax Profile. Available on the Internet at: http://www.borax.com/sereport03. Accessed December 30, 2004.

Sakata, M. 1987. Relationship between adsorption of arsenic (III) and boron by soil and soil properties. *Environmental Science and Technology*. 21:1126-1130. (As cited in ATSDR, 1992.)

Seidel, C. 2006. Email Communication to Brent Ranalli at The Cadmus Group, Inc. [concerning boron data from an AwwaRF-sponsored study, with data in an attached spreadsheet]. Denver, CO: McGuire Malcolm Pirnie. May 19.

United States Environmental Protection Agency (USEPA). 1987. *Toxic Air Pollutant/Source Crosswalk: A Screening Tool for Locating Possible Sources Emitting Toxic Air Pollutants*. Office of Air Quality and Planning Standards. EPA 450/4-87-023a. (As cited in ATSDR, 1992.)

USEPA. 1994a. *Reregistration Eligibility Decision (RED) - Boric Acid and its Sodium Salts*. Office of Prevention, Pesticides, and Toxic Substances. Available on the Internet at: http://www.epa.gov/oppsrrd1/REDs/old_reds/boric_acid_salts.pdf.

USEPA. 1994b. Method 200.7: Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry Revision 4.4. Martin, T.D., C.A. Brockhoff, J.T. Creed, and EMMC Methods Work Group. In: *Methods for the Determination of Metals in Environmental Samples Supplement 1*. EPA 600-R-94-111.

USEPA. 2002a. *Community Water System Survey 2000. Volume I: Overview*. EPA 815-R-02-005A. December. Available on the Internet at: http://www.epa.gov/safewater/consumer/pdf/cwss_2000_volume_i.pdf.

USEPA. 2002b. *Community Water System Survey 2000. Volume II: Detailed Tables and Survey Methodology*. EPA 815-R-02-005B. Available on the Internet at: http://www.epa.gov/safewater/consumer/pdf/cwss_2000_volume_ii.pdf.

USEPA. 2004a. Integrated Risk Information System (IRIS), Boron and Compounds. August. Available on the Internet at: http://www.epa.gov/iris/subst/0410.htm. Accessed February 2, 2005.

USEPA. 2004b. *Toxicological Review of Boron and Compounds.* EPA 635-04-052. June. Available online at: http://www.epa.gov/iris/toxreviews/0410-tr.pdf.

USEPA. 2006. TRI Explorer: Trends. Search for boron trichloride, boron trifluoride. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. Accessed February 8, 2006. Last updated June 8, 2005,.

USEPA. 2008. *The Analysis of Occurrence Data from the Unregulated Contaminant Monitoring (UCM) Program and National Inorganics and Radionuclides Survey (NIRS) in Support of Regulatory Determinations for the Second Drinking Water Contaminant Candidate List*. EPA 815-D-08-014. June.

United States Geological Survey (USGS). 2004. Mineral Commodity Summaries, January 2004--Boron. Available on the Internet at: http://minerals.usgs.gov/minerals/pubs/commodity/boron/boronmcs04.pdf.

Waggot, A. 1969. An investigation of the potential problem of increasing boron concentrations in rivers and water courses. *Water Research*. 3:749-765. (As cited in ATSDR, 1992.)

Warner, K.L. 1999. *Analysis of nutrients, selected inorganic constituents, and trace elements in water from Illinois community-supply wells, 1984-91*. U.S. Geological Survey Water-Resources Investigations Report 99-4152. 47 pp. Available on the Internet at: http://il.water.usgs.gov/proj/lirb/pubs/pdfs/topicalbook.pdf.

Weast, R.C. (ed.). 1988. *CRC Handbook of Chemistry and Physics*. 68th ed. Boca Raton, FL: CRC Press Inc. (As cited in ATSDR, 1992 and HSDB, 2004.)

Windholz, M., S. Budavari, R.F. Blumetti, E.S. Otterbein (eds.) 1983. *The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals*. 10th Edition. Rahway, NJ: Merck and Co., Inc.

Wong, J.M. 1984. Boron Control in Power Plant Reclaimed Water for Potable Reuse. *Environmental Progress*. 3(1):5-11.

EXHIBIT D

Summary Document from the Health Advisory
for
Boron and Compounds

Prepared by Health and Ecological Criteria Division (HECD), Office of Science and Technology (OST), Office of Water (OW) for Office of Groundwater/Drinking Water (OGWDW), OW, U.S. EPA.
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This is a Summary derived from the Health Advisory for Boron and Compounds, unregulated contaminants occasionally found in drinking water. Health Advisories (HAs) serve as informal guidance on the concentrations of chemicals that may raise a health concern when spills or contamination situations occur. They are prepared for the Federal, State and local officials responsible for protecting public health. The guideline values are not enforceable Federal standards and are subject to change as new information becomes available.

What is boron?

Boron is a non-metallic, naturally-occurring, element found in rocks, soil, and water. Boron does not exist as a pure element but is combined with oxygen as borate minerals and various boron compounds such as boric acid, borax, and boron oxide. The boron compounds listed above are odorless crystals, granules, or powders. Elemental boron is insoluble in water and boric acid and borax are slightly soluble in water.

What are the uses of boron and its compounds?

Boron compounds are used primarily in the production of glass and ceramics, pesticides, fire retardants, plus insulation-grade- and textile-grade-glass fibers. Boron can be present in commercial plant foods and fertilizers. Boron compounds are often found in household laundry and cleaning products.

How does boron get in my drinking water?

Boron gets into drinking water from both naturally-occurring and man-made sources. Some areas in the western United States (California, Nevada, Oregon) have high concentrations of boron in some of their soils. Contamination of water can come directly from industrial wastewater and municipal sewage, as well as indirectly from air deposition and soil runoff. Natural weathering processes, burning of coal in power plants, chemical plants, and manufacturing facilities releases boron into the air; and fertilizers, herbicides, and industrial wastes are among the sources of soil contamination.

How much boron am I exposed to from sources other than in my drinking water?

Approximately 800,000 to 4,000,000 metric tons of boron are released into the atmosphere from sea water, and about 180,000 to 650,000 metric tons of boron are released into the atmosphere from the industries that use boron and boron-containing products. Boron concentrations in the air are reported to range from <0.5 to 80 ng/m^3. Boron is found in soil and is taken up by plants. It found naturally in fruits, legumes, nuts, vegetables, and grains. The average intake of boron in the U.S. diet ranges from 0.85 mg B/day (4-8 year old child) to 1.47 mg B/day (male vegetarian). Dietary levels can be as high as 5-6 mg/day for some individuals.

What adverse health effects have been observed in humans and animals exposed to high levels of boron?

An acute overdose to infants has caused diarrhea, vomiting, signs of irritability, erythema in the diaper area, a mild red rash on the face and neck, a pus-like discharge or mild congestion of the eye, and possibly convulsive seizures. In adults, an acute overdose causes nausea, vomiting, redness of the skin, difficulty swallowing due to ulcers in the throat, and a non-bloody diarrhea. In animals, acute excessive exposure has caused lethargy, rapid respiration, eye inflammation, swelling of the paws, shedding of the skin on the paws and tails, excitation during handling, and changes in the cells of the forestomach.

What are the amounts of boron and compounds that might cause adverse health effects?

As levels of boron in drinking water increase above the One-Day and Ten-Day Health Advisory (3.0 mg/L) and the Longer Term Health Advisory (2.0 mg/L) for children, the risk for the potential effect on the testes of young males increases when consumed for the duration indicated by the advisory. As the level of boron in drinking water increases above the Longer Term Health Advisory and Lifetime Health Advisory for adults (5 mg/L), the risk for the potential effect on the fetuses of pregnant women and the testes of males increases. Direct effects on a pregnant woman would occur at doses higher than those that would affect the fetus. Data are not available to assess any potential differences in susceptibility of pregnant vs. non-pregnant women. Water containing boron at levels above the HA should not be used to prepare food or formula for infants and children.

How will I know if I have boron in my drinking water?

The Federal Government does not regulate boron in drinking water and, public drinking water systems are not required to monitor for this contaminant. Some states have drinking water standards or guidelines for boron (California, Florida, Maine, Minnesota, New Hampshire and Wisconsin); these range from 0.6 to 1 mg/L. You may want to call your drinking water utility or state drinking water program to determine if monitoring is required in your state.

If there is no requirement for monitoring in your state, you can have your water analyzed by a laboratory that is certified for the analysis of similar compounds. The following EPA website provides a list of state certification officers or links to certified laboratories in your state: http://www.epa.gov/safewater/labs/index.html. The contacts provided may be able to assist you in finding an appropriate laboratory.

You can also call your local public health office or the Safe Drinking Water Hotline *Phone: 800-426-4791- toll free*; http://www.epa.gov/safewater/hotline/index.html to determine if they are aware of any problems with boron in your area.

How can boron be removed if it gets in my drinking water?

Three technologies have been shown to reduce boron levels to below 0.3 mg/L. They are a boron-specific ion exchange resin, a strong-base anion-exchange resin, and reverse osmosis, which has limited capabilities. Before installing a home treatment unit, the manufacturer should be contacted to determine if it can remove boron from your water supply.

How can I find out more about boron?

The Drinking Water Health Advisory will provide additional detail about boron. You can access the Health Advisory at www.epa.gov/waterscience/.

Reference

United States Environmental Protection Agency (U.S. EPA). 2008. Drinking Water Health Advisory for Boron and Compounds. *Prepared by Health and Ecological Criteria Division (HECD), Office of Science and Technology (OST), Office of Water (OW) for Office of Groundwater/Drinking Water (OGWDW), OW, U.S. EPA.*