IMOA
THE VOICE OF THE MOLYBDENUM INDUSTRY

17 June 2024

To: Illinois Pollution Control Board

Fr: International Molybdenum Association

Re: R22-18 – IMOA response to the First Notice publication by IPCB proposing amendments to part 620 of its groundwater quality regulation in relation to molybdenum

During the ongoing rule-making process the International Molybdenum Association (IMOA) has made multiple detailed written submissions and an IMOA representative (the undersigned) also gave verbal in-person testimony at the 21June 2022 hearing in Springfield, Illinois.

On each occasion IMOA has respectfully requested that any ruling on molybdenum be deferred until such time as the rule-making bodies can take into account the wealth of more recent, robust science assessed in the 2020 US ATSDR Toxicological Profile for Molybdenum. Such a measure is requested instead of Illinos EPA's (IEPA) use of the IRIS database entry for molybdenum, which was written in 1992, never updated, and from which all more recent best available science is totally absent.

Given the imminent IEPA rulemaking decisions, it is imperative that Illinois take heed that (as recently as May 2024), the federal EPA Region 8 has definitively agreed that the US ATSDR Toxicological Profile does, in fact, provide "the most relevant and highest confidence toxicity and exposure information currently available," as explained below.

IEPA continues to cite Tier 1 toxicity data hierarchy rules to justify using the IRIS 1992 vastly outdated assessment based on a low-confidence study (Koval'sky 1961), instead of the nearly three decades more-recent 2020 US ATSDR government agency assessment. IMOA considers it highly questionable how this IEPA approach could be optimal or appropriate when IRIS relies on data that is so far remote from best available science, and yet IEPA chooses to rely on that IRIS data. US ATSDR, in their 2020 Toxicological Profile for Molybdenum, assessed the confidence levels of the range of currently available studies, from the OECD test protocol-compliant GLP human health studies, (90-day repeated dose toxicity study, 1st species PNDT study, and likewise a 2-Generation reproductive toxicity study, all peer-review published by lead author Dr. Jay Murray and ranked 'high confidence') through to the above-mentioned Koval'sky study. ATSDR ranked the latter as a 'low confidence study' and assessed it as follows:

Page A-22 of Appendix A of the ATSDR Toxicological Profile for Molybdenum:

> Although the Koval'sky et al. (1961) study provided an estimated dose, the study was not considered suitable for derivation of a chronic-duration oral MRL for molybdenum. The study has a number of deficiencies that limit the interpretation of the results: (1) the control group consisted of 5 individuals compared to 52 subjects in the exposed group; (2) no information was provided on the controls to assess whether they were matched to the exposed group; (3) it does not appear that the study controlled for potential confounders, such as diet and alcohol, which can increase uric acid levels; and (4) NAS (2001) noted that there were potential analytical problems with the measurement of serum and urine copper levels.

Page C-32 of Appendix C of the ATSDR Toxicological Profile for Molybdenum:

- Alterations in uric acid levels
  - Low evidence of an effect in cross-sectional studies (Koval'skiy et al. 1961; Walravens et al. 1979).
  - High confidence in an animal study not finding an effect (Murray et al. 2014a).

Using this low confidence Koval'sky study as its basis, IEPA is proposing a groundwater quality standard value, originally proposed as 19 µg Mo/L and more recently even subject to a further reduced proposal of 10 µg Mo/L. It is IMOA's informed opinion that either of those levels are supported whatsoever by currently available high quality studies.

To assist the Illinois Pollution Control Board with meaningful insights into Mo values derived for human health based water quality standards in other US states recently *where assessments are being based on the currently available relevant scientific studies in the US ATSDR 2020 Toxicological Profile for Molybdenum,* we share the following information:

- Wisconsin Dept. of Health Services: Their published WQS formula, applied correctly, derives a groundwater standard for molybdenum of 600 µg Mo/L. More info: (https://www.dhs.wisconsin.gov/water/gws.htm). Website extract shown below:

  Molybdenum

  The groundwater standards for molybdenum were adopted in Cycle 8 (2006). In Cycle 10 (2019), DHS recommended revising the standards to be based on information from the Agency for Toxic Substances and Disease Registry (ATSDR).*

  Current Enforcement standard = 40 µg/L
  Current Preventive action limit = 8 µg/L

  Molybdenum is a common element found in minerals, rocks, and soil. It is used in many industrial processes. Studies have shown that high levels of molybdenum can cause kidney and liver damage and impact reproduction and development.

  *The recommended enforcement standard was erroneously calculated to be 10-fold lower than it should have been. In April 2024, we withdrew the recommended groundwater standard of 60 micrograms per liter (µg/L) and the recommended preventive action limit of 6 µg/L.

  Wisconsin Dept. of Natural Resources has provided written assurance to IMOA in May 2024 that molybdenum will be included in their next cycle of groundwater rule development.

- Colorado Department of Public Health & Environment are in the process of determining a human-health based water quality standard of 530 µg Mo/L for a river segment into which there is outflow from a molybdenum mine.

Elsewhere globally, in the Flanders area of Belgium in Europe, in the vicinity of a molybdenum processing plant, the soil to groundwater remediation value is approved by the relevant authorities (OVAM) at 2,190.00 µg Mo/L.

The hazard and risk assessments for each of the above examples specifically elected *not* to use the IRIS database for molybdenum for reasons of its unacceptable outdatedness for current regulatory purposes, amply demonstrating there are recent assessments that deviate from EPA's 'standard' data hierarchy guidance.

IEPA also argues that it is inappropriate 'to use the sub-chronic value for evaluating chronic exposure without applying an additional uncertainty factor of 10 for sub-chronic to chronic extrapolation'. By way of comparison however, recently in the course of the above-mentioned Colorado rule-making process, EPA Region 8 concluded the opposite, i.e. 'the evidence available from molybdenum studies for kidney health effects, the most sensitive endpoint reported following repeated molybdenum exposure (ATSDR 2020), supports the conclusion that application of an uncertainty factor to account for sub-chronic to chronic exposures is *unnecessary* for the intermediate duration oral MRL'. EPA Region 8 concludes use of the 2020 ATSDR information will allow 2024 regulatory standards to be "based upon the most relevant and highest confidence toxicity and exposure information currently available." For more detailed information please see the attached EPA Region 8 document, particularly pages 4 – 5, paragraphs 6 – 11 of its Enclosure.

For the reasons provided above, we therefore once again respectfully request that any ruling involving molybdenum be deferred until such time as IEPA are able to take into consideration the more recent best available science assessed by the US government agency ATSDR in 2020.

Kind regards.

Sandra Carey

Sandra Carey

IMOA HSE Executive

References:

EPA Region 8: Proposed changes to molybdenum WQS, A. Todd, dated 24.04.03, highlighted Reference Dose section on pages 4 – 5, paragraphs 6 – 11 of the Enclosure.

Koval'skiy VV, Yarovaya GA, Shmavonyan DM. 1961. Changes of purine metabolism in man and animals under conditions of molybdenum biogeochemical provinces. Zh Obshch Biol 22(3):179-191.

NTP (1997). NTP Technical Report on the Toxicology and Carcinogenesis Studies of Molybdenum Trioxide in F344/N Rats and B6C3F/1 Mice (Inhalation Studies). National Toxicology Program. NTP TR 462. NIH Publication No. 97-3378.

OVAM (Belgium) letter dated 31 July 2019 to Belgian molybdenum processing plant – available on request to IMOA

US ATSDR Toxicological Profile for Molybdenum, May 2020.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
DENVER, CO 80202

Ref: 8WD-CWQ

SENT VIA EMAIL

Mike Weber, Chair
Colorado Water Quality Control Commission
cdphe.wqcc@state.co.us

Subject: Proposed Changes to Molybdenum WQS

Dear Mr. Weber:

The purpose of this letter is to provide U.S. Environmental Protection Agency Region 8 comments on the changes to Colorado water quality standards (WQS) proposed by the Climax Molybdenum Company (Climax).

Our review has addressed the proposed WQS rule changes and supporting analyses submitted by Climax with their March 6, 2024 proponent's prehearing statement. Our comments are preliminary in nature. Prior to acting on any WQS revisions that may be adopted by the Water Quality Control Commission (WQCC or Commission), EPA would review all pertinent issues, including information/comments that are submitted and testimony at the public hearing.

CWA § 303(c)(2) requires States and authorized Indian Tribes to submit new or revised WQS to EPA for review.[1] EPA is required to review and approve or disapprove the revisions. New or revised WQS do not become applicable WQS for CWA purposes until they are approved by EPA (40 C.F.R. § 131.21). Pursuant to CWA § 303(c)(3), if EPA determines that any WQS is not consistent with the applicable requirements of the Act, the Agency shall, not later than the ninetieth day after the date of submission, notify the State or authorized Tribe and specify the changes to meet the requirements. If the changes are not adopted within ninety days after the date of notification, EPA is to propose and promulgate such WQS pursuant to CWA § 303(c)(4). The Region's goal has been, and will continue to be, to work closely with States and authorized Tribes throughout the standards revision process so that submitted revisions can be approved by EPA.

[1] CWA § 518(e) specifically authorizes EPA to treat eligible Indian tribes in the same manner as states for purposes of CWA § 303. See also 40 C.F.R. § 131.8.

Proposed WQS Changes

Climax proposes to revise 1) Regulation #33, specifically the molybdenum numeric standard for protection of the water supply use classification assigned to Blue River segment 14 (a portion of Tenmile Creek above Dillon Reservoir), and 2) the molybdenum table value standard (TVS) for the water supply use classification in Regulation #31. With regard to both regulations, the proposal is to delete the current value (210 µg/L) and adopt an updated value (1,600 µg/L).

Summary of EPA Comments

The proposed revision to the molybdenum TVS for the water supply use classification, with the reference dose (RfD) based upon the ATSDR intermediate oral minimum risk level (MRL) of 0.06 mg/kg-day, a relative source contribution (RSC) of 0.8, and updated exposure assumptions regarding adult body weight (80 kg) and daily water intake rate (2.4 L/day), appears to be appropriately protective based upon the most relevant and highest confidence toxicity and exposure information currently available.

Conclusion

EPA appreciates having an opportunity to provide comments on the proposed changes to the molybdenum WQS. Any questions about our comments may be directed to Dave Moon (moon.dave@epa.gov) and Jason Fritz (fritz.jason@epa.gov).

Sincerely,

Andrew S. Todd, Supervisor
Water Quality Section

Enclosure

Enclosure

EPA Region 8 Comments on Proposed Changes to Molybdenum WQS

History of the Issue

The molybdenum water supply standard was first assigned to Blue River segment 14 in 2014, along with a segment-specific temporary modification. The expiration date of the temporary modification was extended by three years in 2017 and again in 2020. EPA approved each of these WQS revisions. Today, the temporary modification is no longer in effect and has expired (EPA did not act on a six-month extension from 6/30/2023 to 12/31/2023 and instead provided recommendations regarding extension proposals).[2] Unlike the temporary modification, the 210 µg/L numeric standard remains in effect on Blue River segment 14 and would be revised by the Climax proposal, along with the Regulation #31 TVS for the water supply use classification.

How was the Current Molybdenum Standard Calculated?

The current molybdenum standard for the water supply use classification (adopted into Regulation #31 in 2010) was calculated using Equation 1-1 in WQCC Policy 96-2:

$$TVS = \frac{\text{RfD x Body Weight x RSC x 1000 µg/mg}}{\text{Water Intake x UF}} = \frac{0.03 \times 70 \times 0.2 \times 1000}{2 \times 1} = 210\ \mu g/L$$

where:
RfD or Reference Dose = 0.03 mg/kg-day
Body Weight = 70 kg
RSC or Relative Source Contribution = 0.2 (20% of RfD is allocated to exposure via water intake)
Water Intake = 2 liters/day
Uncertainty Factor = 1X (default value)

Which of the Variables Would be Changed?

The Climax proposal would:

- Increase the RSC by 4X to 0.8 (80% of RfD is allocated to exposure via water intake)
- Increase the RfD by 2X to 0.06 mg/kg-day
- Increase the Body Weight to 80 kg (consistent with the 2020 Colorado WQS revisions)
- Increase the Water Intake to 2.4 liters/day (consistent with the 2020 Colorado WQS revisions)

EPA Comments

1. Regarding Colorado's molybdenum WQS for protection of the water supply use classification, EPA appreciates the efforts made by Climax and the Division, as well as participating stakeholders that may be affected by the quality of ambient source waters such as Tenmile Creek.

[2] See EPA's December 8, 2022 WQS action letter https://drive.google.com/file/d/15ia7w_b35RP8q4y3-CwVDijJy9mBZlU_/view

2. EPA has an oversight role whenever new or revised WQS are adopted. Pursuant to 40 C.F.R. Section 131.20(c), states must submit WQS changes and supporting analyses to EPA for review and approval.

3. When reviewing changes to ambient water quality criteria, EPA's decisions must be consistent with its implementing regulation at 40 C.F.R. Part 131, which is explicit that states and authorized tribes must adopt criteria that are *protective* of the designated use based on sound scientific rationale (40 C.F.R. § 131.11(a)(1)). Once a scientifically defensible WQS has been established, the CWA allows for the costs of compliance and other attainability factors to be considered (e.g., in an engineering alternatives analysis to support a discharger-specific WQS variance).

4. The methodology used to derive table value standards should be appropriately conservative, such that the resulting values can be assigned to individual segments statewide with confidence that designated uses will be protected.

5. The proposed approach appears to be approvable. However, EPA recognizes that the CWA gives States the lead role in determining appropriate water quality standards (CWA §§ 101(b), 303(c)), and that States have risk management discretion in deriving ambient water quality criteria (CWA § 510), provided the criteria will protect the designated use based on a sound scientific rationale (40 CFR § 131.11(a)(1)). Accordingly, EPA would have no objection if the Commission elects to utilize an approach that is more health-protective or conservative than the one proposed by Climax.

Reference Dose (RfD)

6. The choice of the intermediate duration oral minimal risk level (MRL) derived by the US Agency for Toxic Substances and Disease Registry (ATSDR, 2020) is the appropriate choice of RfD for use in the proposed molybdenum (Mo) WQS for the protection of the water supply use classification. The ATSDR (2020) Toxicological Profile for Molybdenum is a comprehensive, independent, assessment of the relevant experimental and epidemiological evidence by a Federal public health agency. While EPA's methods for developing health assessments differ in some regards, including uncertainty factor selection, ATSDR Toxicological Profiles are developed by a Federal agency that is an authority in public health protection (e.g., USEPA, 2003).

7. ATSDR (2020) chose the point of departure (POD) of 17 mg/kg-day as a no observed adverse effect level (NOAEL) based upon kidney effects (renal proximal tubule hyperplasia) from the 90-day subchronic dietary exposure study in rats reported by Murray et al., (2014a), as the most sensitive endpoint among the available evidence of sufficient quality and reliability.
   a. While USEPA and ATSDR methodologies differ in some regards when it comes to deriving RfDs (USEPA, 2012) or MRLs (ATSDR, 2020), ATSDR applied uncertainty factors (specifically, an intraspecies uncertainty factor of 10, and an interspecies uncertainty factor of 10) in a manner consistent with their methodology, and in consideration of recommendations from independent scientific review to account for various sources of uncertainty.

8. In alignment with USEPA recommendations (USEPA, 2002), after a comprehensive evaluation of the available database, ATSDR (2020) also applied a modifying factor of 3 (combined with the uncertainty factors described above, for a total composite adjustment of 300) to account for additional uncertainty regarding the potential for increased susceptibility in sensitive populations where copper intake was a concern, potentially in developing humans.

9. While molybdenum is essential for life, it is notable that the database is relatively limited, in that it appears to lack the quantity and quality of studies reporting adverse health outcomes in human

populations compared with other agents described in the proposal (collectively "essential elements"), and specifically a lack of information from exposures to potentially sensitive lifestages such as young children, pregnant women, the elderly and/or adults with pre-existing health conditions, such as kidney disease. The database also lacks studies on more subtle outcomes, such as neurological effects in children or adults. Furthermore, there are no identified human populations known to be experiencing molybdenum deficiency, so there are no data to suggest that regulation of molybdenum intake would decrease intake below a biologically necessary level.

  a. This lack of human studies of sufficient quality and confidence, which assessed health effects after chronic and/or developmental exposures, likely contributes to the increased level of uncertainty reflected in the uncertainty and modifying factors applied by ATSDR (2020), compared with previous assessments by ATSDR and USEPA.

10. ATSDR determined that there was insufficient evidence to derive a chronic oral MRL. This suggests that there could be uncertainty regarding the potential for kidney effects observed after 90 days of exposure in adult rats (intermediate duration) to increase in severity, or emerge at lower doses, following chronic exposures. While ATSDR does not typically consider the application of an uncertainty factor to shorter-duration exposure studies in the evaluation of chronic MRLs, USEPA does routinely consider this adjustment in hazard assessments (2002).
    a. However, there is evidence available from another study evaluating molybdenum effects which suggests that additional adjustment is unnecessary.
    b. ATSDR based a chronic inhalation MRL upon outcomes reported in a 2-year inhalation exposure bioassay conducted in rats by the National Toxicology Program (NTP, 1997; ATSDR, 2020). In this study NTP measured blood levels of molybdenum following chronic molybdenum trioxide inhalation exposure, and blood molybdenum levels were similar to those reported in rats following 90-days exposure at 17 mg/kg-day via diet by Murray et al., (2014a), which was the study and dose used by ATSDR as the basis for the intermediate duration oral MRL.
    c. As the kidney is a highly perfused organ, it is exposed to molybdenum primarily via blood circulation, following oral or inhalation exposures. Since the blood molybdenum levels were similar in the rats exposed for 90-days via diet (Murray et al., 2014a) and for 2-years via inhalation (NTP, 1997), the kidney outcomes reported after either 90 days or 2 years of exposure can be qualitatively compared to determine if they are also similar.
    d. Because NTP (1997) found no evidence of kidney effects in the rodents after 2 years of exposure to similar blood molybdenum levels as the 90-day study dose group which also reported no effects, this provides one line of evidence from studies of molybdenum exposure that the intermediate duration oral MRL (ATSDR, 2020) may be sufficiently protective of kidney effects after chronic exposure.

11. The evidence available from molybdenum studies for kidney health effects, the most sensitive endpoint reported following repeated molybdenum exposure (ATSDR, 2020), supports the conclusion that application of an uncertainty factor to account for subchronic to chronic exposures is unnecessary for the intermediate duration oral MRL. However, it would not be constructive or appropriate to broadly apply this conclusion to evaluations of other agents as an *a priori* assumption; rather, the database for each compound should be evaluated appropriately according to current Agency guidance (e.g., USEPA 2002; USEPA, 2012).

<u>Exposure Assumptions</u>

12. A relative source contribution (RSC) of 0.8 was derived using the subtraction method and is based upon available information to understand central tendencies and reasonable maximal exposures in the general population. While the "Exposure Decision Tree for Defining Proposed RfD (or POD/UF)

Apportionment" (USEPA, 2000) does include the subtraction method as one option to determine relative contributions from non-drinking water sources in the evaluation for the molybdenum WQS, it is also informative to evaluate potential contributions from all sources using the percentage approach, which is employed below (USEPA, 2015a; USEPA, 2015b).

13. Contribution to daily molybdenum intake from sources other than drinking water should be estimated using average intake rates (USEPA, 2000), although at times, evaluating upper confidence limits of averages may provide a useful upper bound for consideration. However, the use of high-end intakes for every exposure source is not recommended, since the combination of a series of highest-estimate exposure scenarios may not be representative of any actually exposed individual or population (USEPA, 2000).

14. Using the ATSDR intermediate oral MRL as the RfD (ATSDR, 2020), as proposed, the total allowable daily intake would be: 0.06 mg Mo/kg body weight per day x 80 kg body weight = **4.8 mg Mo/day**.
    a. Using the combination of average adult body weights and 90^{th}-percentile water intake rates is appropriate, as the ambient water WQS is intended to be adequately protective of a human population over a lifetime of exposure (USEPA, 2000; USEPA, 2015a; USEPA, 2015b).
    b. These body weights and intake rates can be adjusted for specific lifestages which may be sensitive target populations, if desired by states and tribes, in which case, consideration of subchronic or acute toxicity would likely be recommended (USEPA, 2000; USEPA, 2015b).
    c. However, the RfD was based upon the most sensitive effect observed in reliable studies of sufficient quality, i.e., kidney effects in adult rats (ATSDR, 2020). The available animal toxicology evidence (primarily an OECD guideline developmental toxicity study (Murray et al., 2014b), an OECD supplemental prenatal developmental toxicity study (Aveyard et al., 2023), and a two-generation reproductive toxicity study (Murray et al., 2019)) does not suggest that young or pregnant animals are more sensitive to molybdenum toxicity.

15. Potential contribution from inhalation via ambient air: evidence from available national studies of ambient air levels of molybdenum in several states (ATSDR, 2020) suggests that inhalation would *contribute < 0.001% towards an estimated daily molybdenum intake*.
    a. The highest end of the range reported, 0.03 $\mu g/m^3$, would equate to approximately 0.6 µg Mo/day, which is 0.0006 mg/4.8 mg or < 0.001%.
    b. However, there was no information available for Colorado specifically, or for areas which may have high ambient molybdenum air concentrations, e.g. areas with high molybdenum surface contents and/or in close proximity to molybdenum extraction or refining operations. While this is a data gap, the ambient air levels would have to be >100-times higher to even reach 1% of the allowable daily intake.
        i. Notably, one historical account of Colorado worker inhalation exposures to molybdenum in dust from roasting operations was higher (intake estimated at 0.15 mg/kg-day in Walravens et al., 1979). However, the representativeness of this estimate to other workplace exposures is unknown, and estimates from modern operations were not described, so relative contributions from occupational inhalation exposures remains unclear.
    c. For ambient air, using the highest end of the reported range may be considered an upper estimate of average intake considering the uncertainty regarding the relationships between measured ambient air molybdenum concentrations in several US states to that in Colorado.

16. Potential contribution from incidental ingestion of surface soils: Similarly, incidental soil ingestion (i.e., accidental ingestion, from hand-to-mouth activity) would also appear to *likely be <0.01% of daily molybdenum intake*.

a. Levels of molybdenum in the top layers of soils across the US were reported to average 0.78 mg/kg, up to 2.27 mg/kg (95th percentile; ATSDR, 2020).
b. Average incidental soil intake rates for adults vary upon activity, but can range from 50 – 100 mg/day (USEPA, 2017)
c. Average estimate of daily molybdenum intake from soil: 0.78 mg Mo/kg soil x 0.00005 kg soil = 0.000039 mg Mo / 4.8 mg Mo = < 0.001%
d. High end estimate of daily molybdenum intake from soil: 2.27 mg Mo/kg soil x 0.0001 kg soil = 0.000227 mg Mo / 4.8 mg Mo = <0.005%
e. Dermal absorption and uptake of molybdenum is likely negligible compared with incidental ingestion and was not considered further.

17. <u>Potential contribution from diet:</u> Diet is likely the main source of daily molybdenum intake in populations which do not have high molybdenum concentrations in drinking water, and thus the relative contribution of molybdenum in diet is important to estimate. Average daily molybdenum intake from diet has been reported to be 0.180 mg/day in US adults, ranging up to 0.240 mg/day (ATSDR, 2020), *which likely constitutes 5%, and possibly up to 10% of the allowable daily intake*.
    a. Average estimate of daily molybdenum intake from diet: 0.180 mg Mo/ 4.8 mg Mo = 3.75%
    b. High end estimate of daily molybdenum intake from diet: 0.240 mg Mo/ 4.8 mg Mo = 5%
    c. Dietary supplements (e.g., multivitamins) may often contain molybdenum, and at 0.024 mg Mo/day (ATSDR, 2020), this would be: 0.024 mg Mo/ 4.8 mg Mo = 0.5%
    d. Amongst food types, the highest molybdenum concentrations have been reported in legumes, grains, and nuts compared with animal-based products (ATSDR, 2020), which suggests that vegetarian and vegan diets may have higher molybdenum intake. While data specifically on molybdenum intake in people consuming vegetarian diets was not located, reasonable approximations of average molybdenum intakes could be around 130% of that from a meat-containing diet, ranging up to a maximum of 200% (Neufingerl and Eilander, 2021).
        i. This suggests that the molybdenum dietary intake in vegetarian or vegan diets could range around 5% -7.5% of the allowable daily intake, with a maximum estimate of 10%, making the health-protective but likely assumption that vegetarian diets were not a substantial proportion of the population results reported in ATSDR (2020).
    e. Cooking grains and legumes in water with elevated molybdenum concentration may increase molybdenum content in the cooked food. While data is sparse, if rice is taken as a case for maximal water incorporation into food, cooking in water with molybdenum concentrations similar to the proposed TVS doubled the amount of molybdenum per serving of rice (Jaafar et al., 2018).
        i. The impact of this could be increasing daily dietary molybdenum intake by a small margin, i.e. possibly 0.5%.

18. One remaining area of uncertainty regards the extent to which elevated molybdenum content in irrigation water may impact molybdenum content in agricultural crops or residential gardens, including specifically for Colorado communities, as no information was identified which clearly evaluated this.

19. Despite some uncertainties which remain, the contribution from the exposure assumptions and calculations outlined above of all relevant non-water sources to daily molybdenum intake is likely around 5% of the allowable daily intake, and unlikely to be greater than 10%, which suggests that the 80% ceiling RSC value calculated based on Box 13 of the Exposure Decision Tree (USEPA, 2000) applied to the proposed molybdenum drinking water source TVS will be appropriately protective of public health over a lifetime of exposure (USEPA, 2000).
    a. 0.06 mg Mo/kg body weight per day x 80 kg body weight x 0.8 RSC = <u>**3.84 mg Mo/day from drinking water**</u>

Childhood Exposure Considerations

20. The USEPA is committed protecting public health, including sensitive populations, and specifically to protecting "…children from environmental exposures by consistently and explicitly considering early life exposures and lifelong health in all human health decisions." (USEPA, 2021).

21. Because the molybdenum RfD was calculated based upon effects in adult rats from experimental studies, the average adult human is the target population for evaluation of RSC, based on the EPA's 2000 Methodology, as the ambient water WQS is intended to be adequately protective of a human population over a lifetime of exposure (USEPA, 2000; USEPA, 2015a; USEPA, 2015b). For molybdenum, it is illustrative to include some example exposure estimates for developmental life stages to understand the different relative molybdenum ingestion rates that may result, and to consider how the RSC calculated to protect the average adult over a lifetime of exposure relates to other life stages. As shown in Table-1, while TVS values calculated for different life stages change based upon the ratio of body weight to drinking water intake rate, the relative contribution of molybdenum estimated to come from the diet remains below 20% across all lifestages, and below 10% for all but potentially bottle-fed infants.

Table 1 Evaluation of Lifestage-Specific Exposures and Molybdenum (Mo) Intake

Lifestage	Ages	Body weight (average, kg)[a]	Water intake (90%-ile, L/day)[b]	BW / WI ratio[d]	Lifestage-specific-TVS[e] (µg/L)	Total allowable daily intake (ADI) (µg)[f]	Amount of Mo intake from diet (µg)[g]	Percent of Mo intake from diet in ADI
Adult	≥ 21 years	80	2.4	33.3	1,600	4,800	180 – 360	3.8 – 7.5%
Child	6 – 11 years	31.8	0.953	33.4	1,603	1,900	102	5.4%
Child	3 – 6 years	18.6	0.683	27.2	1,306	1,100	66	6%
Infant (breast-fed)	3 – 6 months	7.4	1.037[c]	7.14	343	440	5	1.1%
Infant (bottle-fed)	3 – 6 months	7.4	1.3[c]	5.69	273	440	49	11%

[a] From USEPA (2011); kilograms, kg
[b] From USEPA (2019); liters per day, L/day; 90th percentile of the population, 90%-ile.
[c] Estimates noted as less reliable
[d] Ratio of body weight (BW) / water intake (WI) from TVS equation 1, as a measure of relative drinking water exposure
[e] As shown in Equation 1-1 in WQCC Policy 96-2; with RfD = 0.06 mg/kg-day, RSC = 0.8, additional UF=1x, and all other parameters as noted in the table.
[f] For molybdenum, based upon RfD of 0.06 mg/kg-day and body weight indicated in the table; allowable daily intake (ADI).
[g] Little lifestage specific data available: for children 6-11 years, assumed dietary intake of 3x the recommended daily intake of 34 µg/day for ages 9 – 13 years, and for children 3-6 years assumed dietary intake of 3x the recommended daily intake of 22 µg/day for ages 4 – 8 years (NIH, 2024); for breast-fed infants 3 – 6 months, assumed intake from human breast milk average of 5 µg/L; for bottle-fed infants 3 – 6 months assumed intake from infant formula average of 38 µg/L (Abramovich M et al., 2011)

References:

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