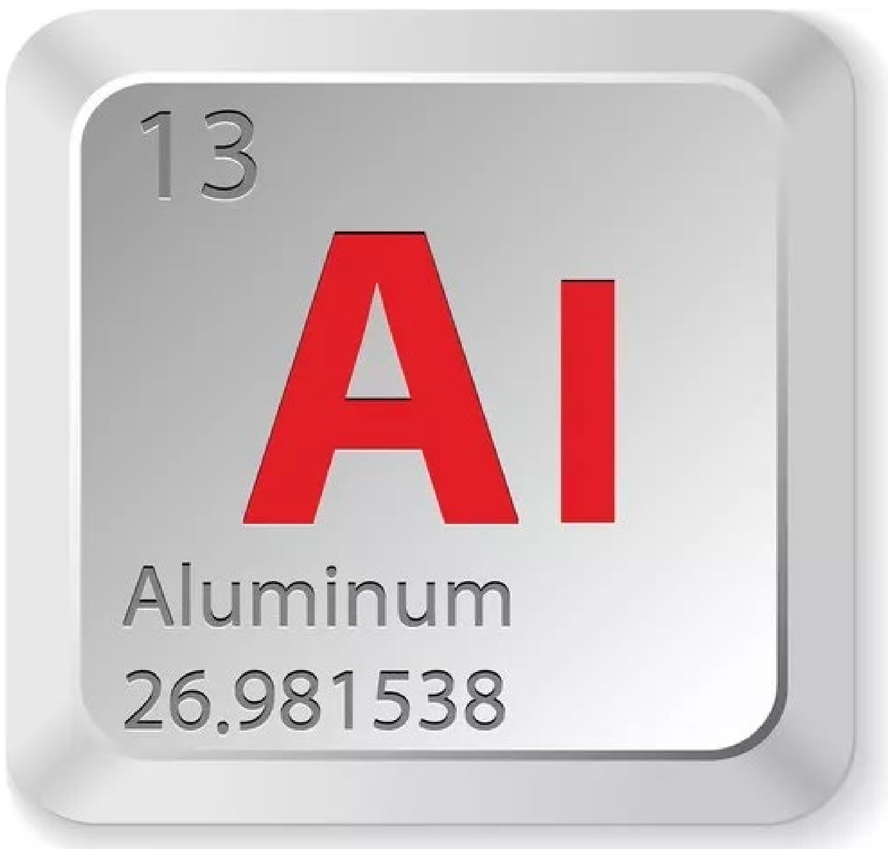
UTAH DEPARTMENT *of*
ENVIRONMENTAL QUALITY
WATER
QUALITY

Aluminum Criteria for the Protection of Aquatic Life



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Criteria Support Document

Review Draft v. 1.0, December 8, 2021

UTAH DIVISION OF WATER QUALITY

Executive Summary

Aluminum is the most abundant metallic element in the earth's crust (Cardelli, 2008) and can be toxic to aquatic life under certain conditions. In 2018, the EPA issued updated criteria for aluminum for the protection of aquatic life. The Utah Division of Water Quality (DWQ) recommends that the Utah Water Quality Board update Utah's standards consistent with the EPA recommendations. The recommended updated criteria are implemented as total recoverable aluminum, the same as Utah's existing criteria. Similar to Utah's current criteria, pH and water hardness affect the updated recommended criteria and a new parameter, dissolved organic carbon, also affects the recommended criteria. The new model for calculating aluminum toxicity is much more accurate than the Utah's current criteria for predicting when aluminum will be toxic.

The recommended criteria are generally anticipated to be less stringent than Utah's existing criteria because of the typical pH, hardness, and anticipated dissolved organic carbon concentrations of most of Utah's surface waters. In the absence of measured dissolved organic carbon concentrations, DWQ is proposing to estimate dissolved organic carbon with the 10^{th} percentile of the EPA ecoregion concentrations for application in discharge permits. For approximately 85% of the UPDES (Utah Pollution Discharge Elimination System) permits, the new criteria are anticipated to be less stringent than the existing criteria. The recommended criteria may be more stringent for 15 UPDES permits. The current maximum anticipated change in the criteria are from 750 µg/l to 640 µg/l. This change is not expected to trigger new effluent limits. Dischargers may opt to measure the dissolved organic carbon concentrations in their receiving waters to replace the 10th percentile assumption and collect additional data to characterize the available assimilative capacity in the receiving waters. Site-specific dissolved organic carbon measurements are anticipated to support less stringent criteria.

DWQ is proposing to delay implementation of the recommended criteria for 3 years to provide an opportunity for dischargers to investigate dissolved organic carbon in their receiving waters and for DWQ to potentially revise assessment methods.

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Introduction

Scope

In the earth's crust, aluminum is most abundant metallic element (Cardelli, 2008). Aluminum generally has low toxicity but can be toxic to aquatic life under specific environmental conditions. In 2018, the U.S. Environmental Protection Agency (EPA) published updated water quality criteria for aluminum for the protection of aquatic life under Section 304(a) of the Clean Water Act (EPA, 2018). Under federal regulations, Utah is obligated to review these updated recommendations and revise Utah's aluminum criteria as appropriate. EPA (2019) has also published a draft Technical Support Document for implementing the criteria.

This DWQ Criteria Support Document contains this review and includes recommendations for updating Utah's statewide aluminum criteria. These criteria for Utah's Class 3 aquatic life uses (UAC R317-2-6), if adopted, may be further modified based on site-specific conditions. Only the Utah Water Quality Board has the authority to change Utah's water quality standards. The Board revises Utah's water quality standards through Utah's rulemaking process. The rulemaking process includes publication in the Utah Bulletin and public participation.

Utah's Current Aluminum Criteria

As specified in UAC R317-2-14, Table 2.14.2, Utah's acute (one-hour) criterion is 750 µg/l and the chronic (four-day) criterion is 87 µg/l. Unlike the criteria for most other criteria for metals and metalloids, the aluminum criteria are expressed as total recoverable aluminum instead of dissolved. Where the pH is equal to or greater than 7.0 and the hardness is equal to or greater than 50 ppm as $CaCO_3$ in the receiving water after mixing, the 87 ug/l chronic criterion (expressed as total recoverable) will not apply, and aluminum will be regulated based on compliance with the 750 ug/l acute aluminum criterion (expressed as total recoverable). For most of Utah's surface waters the acute criterion applies because the pH is usually greater than 7.0 and the hardness commonly exceeds 50 mg/l $CaCO_3$.

EPA (2018) Aluminum Criteria

The EPA (2018) aluminum criteria are adjusted for different water chemistries and are more accurate for predicting when aluminum will be toxic to aquatic life. The EPA (2018) criteria are based on a multiple linear regression model that includes hardness, pH and dissolved organic carbon (DOC). Table 1 shows the possible ranges for these parameters. EPA (2018) has provided a Microsoft Excel spreadsheet, R code, or tables for the acute and chronic criteria. Values outside of the ranges shown in Table 1 do not affect the magnitude of the criteria.

Table 1. Parameter limits of EPA (2018) multiple linear regression model for aluminum criteria

	pH	Hardness	DOC (mg/l)
Range	5.0 - 10.5	0.01 - 430	0.08 - 12

Within the pH range for Utah standards of 6.5 to 9, the EPA (2018) acute criteria exhibit an expansive range of 51 to 4,700 µg/l. For Utah surface waters (pH>7, hardness > 100 mg/l CaCO3, DOC > 0.5 mg/l), the EPA (2018) acute criteria are expected to be less stringent than Utah's current acute criterion of 750 µg/l. The averaging period is one hour, the same as Utah's current criterion.

EPA (2018) chronic criteria range from 33 to 3,200 µg/l and are anticipated to be less stringent for the majority of Utah waters than Utah's current chronic criterion of 87 µg/l. However, for most Utah waters only the current acute criterion of 750 µg/l applies. When Utah's chronic criterion does not apply (pH less than 7 and hardness greater than 50 ppm), the EPA (2018) chronic criterion is often more stringent than the currently applicable acute criterion of 750 µg/l. Note that the averaging period for Utah's 750 µg/l criterion is one hour whereas the EPA (2018) chronic criterion averaging period is four days.

The effects of water chemistry on aluminum toxicity can be complex. The criteria are more sensitive to pH and DOC concentrations than hardness. In general, the criteria are the least stringent at about pH 8 (Figures 1 and 2). The criteria typically are less stringent with increasing DOC concentrations but at higher DOC concentrations, the chronic criteria no longer become more stringent with pH values greater than 8 (Figure 2). As shown on Figures 3 and 4, the criteria are less sensitive to hardness and can be more stringent at higher hardness values.

The EPA (2018) exceedance frequency, the same as the current Utah criteria, is no more than once every three years.

Analytical methods for aluminum

EPA (2018) recommends that the aluminum criteria be implemented based on total recoverable aluminum which is the same as Utah's current criteria. For permits, analytical methods for total recoverable aluminum are specified in 40 CFR Part 136. However, these methods may overestimate the concentrations of bioavailable aluminum, and consequently, the toxicity of aluminum, in ambient waters. EPA discusses these issues in the context of promulgating aluminum criteria for Oregon in the March 19, 2021 Federal Register, 86 FR 14834:

> Over the last three decades, the scientific consensus has been that the total recoverable method for aluminum potentially overestimates the biologically available fraction and that a method that better addresses concerns with including aluminum bound to particulate matter would be useful (e.g., He and Ziemkiewics 2016; Ryan et al. 2019).[6]...
>
> ...EPA expects that an analytical method that uses a less aggressive initial acid digestion that liberates bioavailable forms of aluminum (including amorphous aluminum hydroxide), yet minimizes dissolution of mineralized forms of aluminum such as aluminosilicates associated with suspended sediment particles and

clays (referred to as a bioavailable analytical method), will better estimate the bioavailable fraction of aluminum in ambient waters.

In the criteria promulgated for Oregon, EPA includes a footnote that "a less aggressive initial acid digestion, such as to a pH of approximately 4 or lower, that includes the measurement of amorphous aluminum hydroxide yet minimizes the measurement of mineralized forms of aluminum such as aluminum silicates associated with suspended sediment particles or clays."

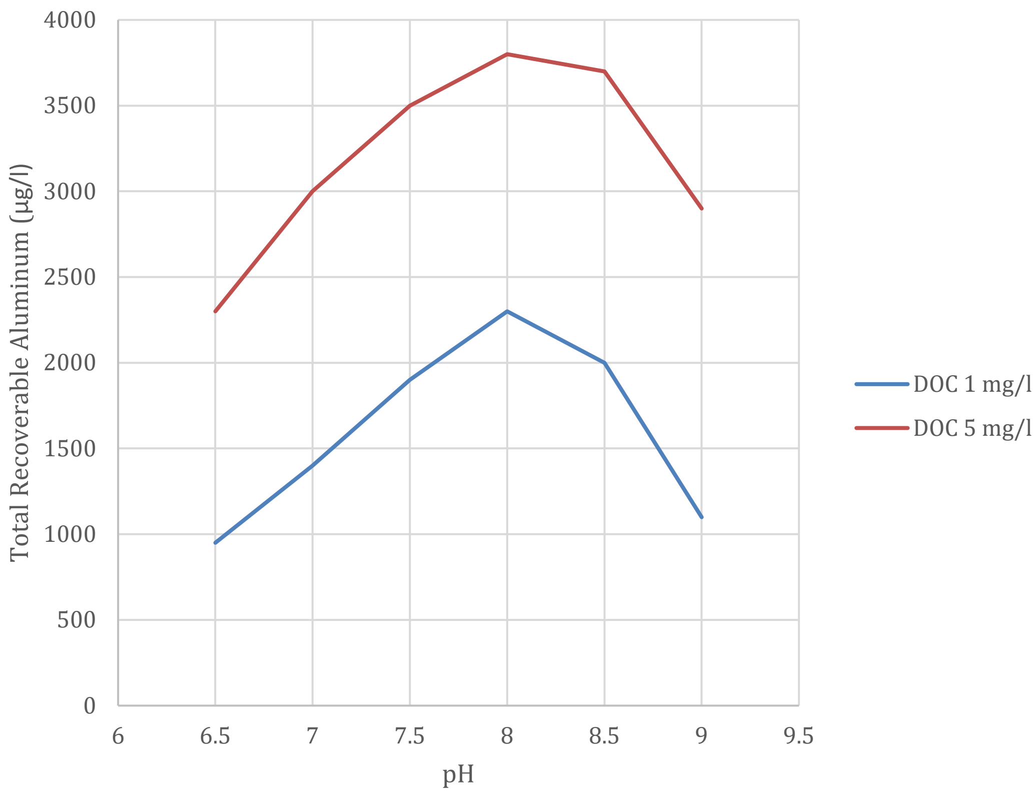

Figure 1. EPA (2018) acute criteria at 300 mg/l hardness and 1 or 5 mg/l dissolved organic carbon (DOC) as pH varies.

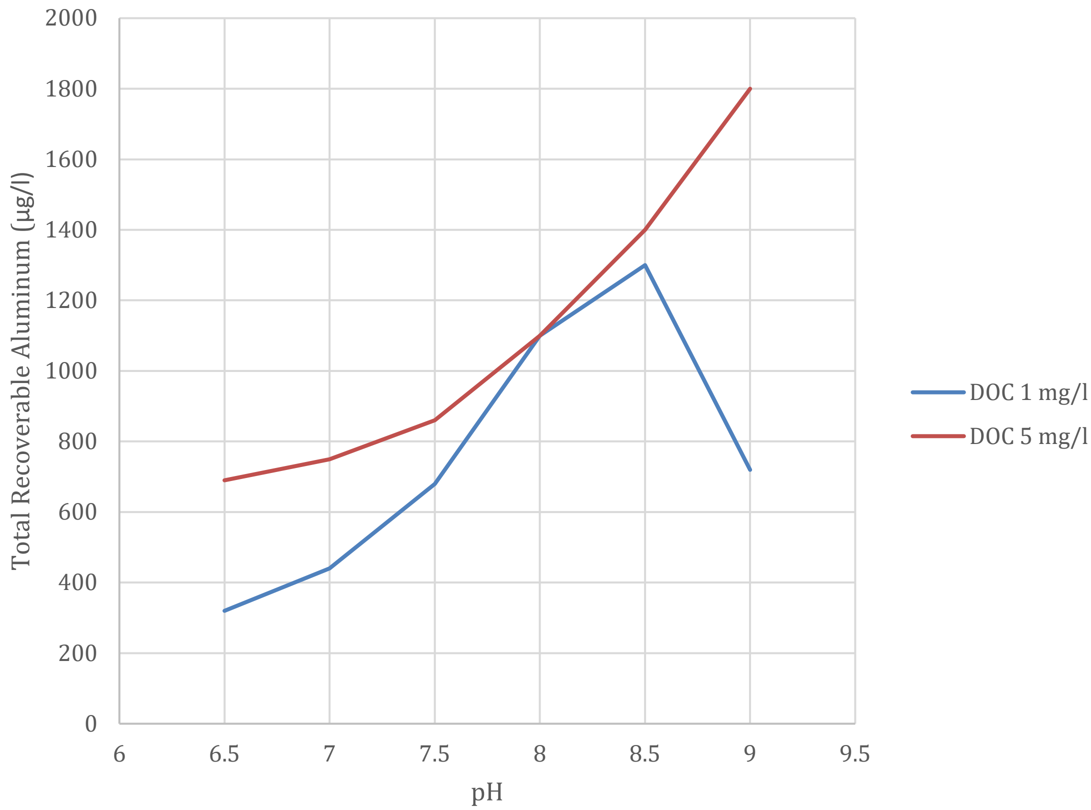

Figure 2. EPA (2018) chronic criteria at 300 mg/l hardness and 1 or 5 mg/l dissolved organic carbon (DOC) as pH varies.

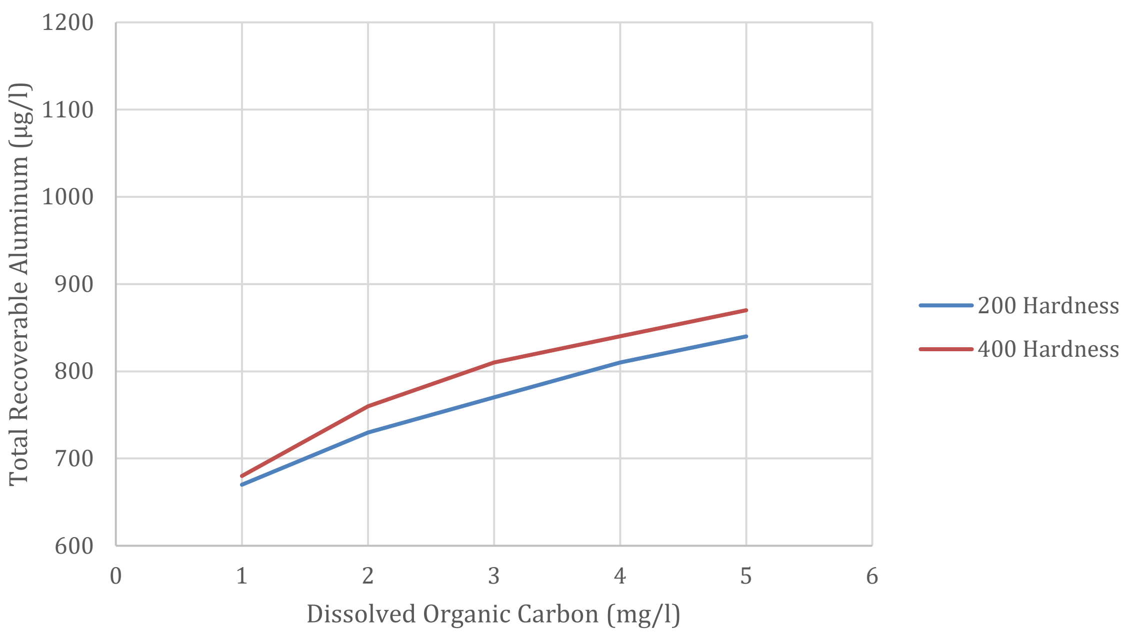

Figure 3. EPA (2018) chronic criteria at pH 7.5 and 200 or 400 mg/l hardness as dissolved organic carbon concentrations vary.

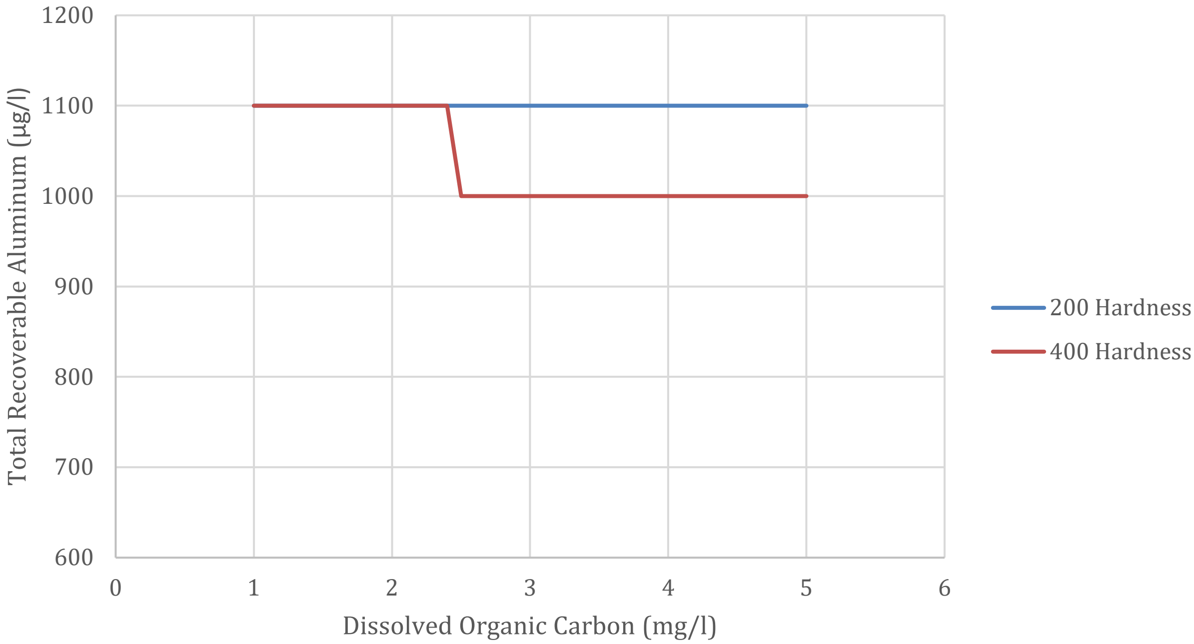

Figure 4. EPA (2018) chronic criteria at pH 8 and 200 or 400 mg/l hardness as dissolved organic carbon concentrations vary.

Recommendations for Utah

The EPA (2018) criteria better predict the toxicity and DWQ recommends updating Utah's criteria. DWQ does not currently routinely analyze for total recoverable aluminum or dissolved organic carbon. The following sections discuss implementation of the new criteria in permits and assessments and the proposed rule language.

Implementation Considerations for Discharge Permits

When compared to Utah's current aluminum criteria, the EPA (2018) criteria requires DOC concentrations for the receiving waters after mixing. For existing discharges, these site-specific data can be collected by the discharger. For new discharges, or when data are not available for existing discharges, DOC concentrations will be estimated (EPA, 2019). EPA (2016) compiled the available DOC data for each state by ecoregion (Figure 1). These data, along with site-specific pH and hardness data, can be used to estimate the EPA (2018) aluminum criteria. Consistent with DWQ's waste load analyses procedures, the criteria should be derived to be protective based on the observed variability for pH, DOC, and hardness.

Table 2 compares Utah's existing aluminum criterion to the EPA (2018) chronic criteria for common Utah water quality conditions of pH 7.5 or pH 8 and hardnesses of 200 or 400 mg/l $CaCO_3$. The DOC concentrations are based on the 10th percentile for the ecoregion (EPA, 2016). For most Utah water quality situations, application of the EPA (2018) criteria based on the 10th percentile DOC concentrations are not anticipated to change existing reasonable potential determinations.

Tables 3 and 4 summarize the current waste load allocations pH and hardness and the EPA ecoregion for existing UPDES permits potentially affected by revised aluminum criteria. Only one permit, UT0024805 has a water quality-based effluent limit for aluminum. If the EPA (2018) criteria are applied using the ecoregion DOC from Table 2, the applicable criteria will be less stringent for 84% of the permits including the permit with a water quality-based effluent limit (Table 3).

For 15 permits, the EPA (2018) criterion will be more stringent by magnitude but the averaging period of 4 days is less stringent than the existing one-hour averaging period (Table 4). The maximum expected change to the criterion is 15%, or a criterion of 640 µg/l instead of 750 µg/l. While these minor changes to the criteria are not expected to affect reasonable determinations, dischargers have the option to measure site-specific DOC concentrations and site-specific total recoverable aluminum in the receiving waters. Site-specific DOC concentrations are expected to be higher than the 10th percentile ecoregion concentrations. If DOC concentrations are higher, less stringent criteria can be supported. If the data are not already available, dischargers can also opt to provide total recoverable aluminum data for the alternative analytical methods discussed in the following section. These methods better reflect the bioavailable aluminum in the receiving waters. If a discharger opts to measure site-specific DOC or total recoverable aluminum in their receiving waters, DWQ should be consulted prior to data collection to ensure that the seasonal and other sources of variability are adequately characterized so that the data can be useable for the waste load allocation.

As previously discussed, effluent monitoring must rely on an approved analytical method for total recoverable aluminum. The receiving water concentrations may be based on the same total recoverable method as the effluent or alternative methods that better characterize the bioavailable fraction of aluminum.

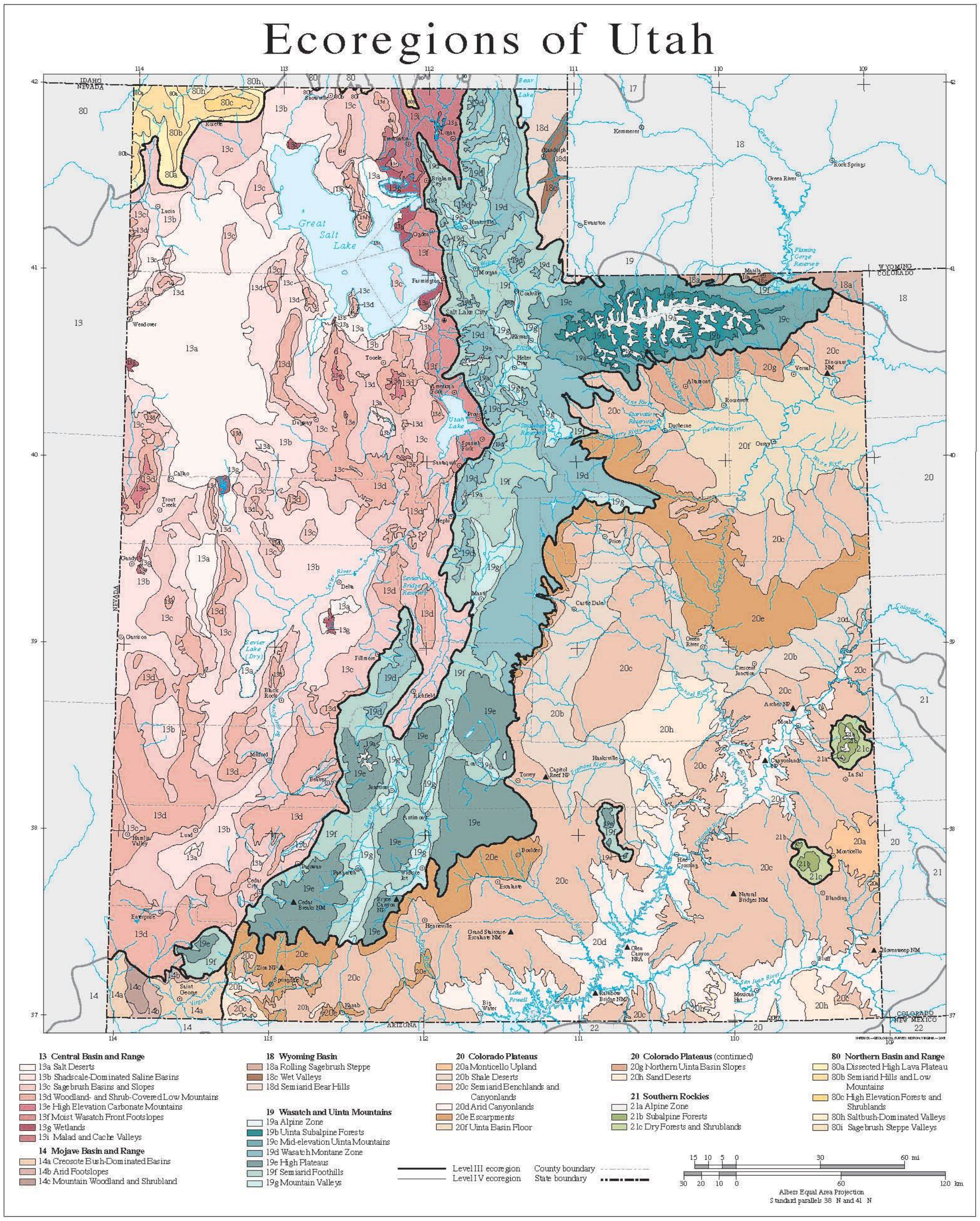

Figure 5. Utah Ecoregions

Table 2. Aluminum Criteria Based on EPA Eco Regional Dissolved Organic Carbon Concentrations

Utah EPA Eco Region	10th percentile DOC	Existing Utah Criteria[1]	EPA (2018)[2]	EPA (2018)[3]	EPA (2018)[4]	EPA (2018)[5]
13	1.5	750	700	1,100	720	1,100
18	4.31	750	820	1,100	850	1,000
19	1.8	750	720	1,100	740	1,000
20	3.0	750	770	1,100	810	1,000
80	1.81	750	720	1,100	740	1,100

Notes

DOC – dissolved organic carbon, mg/l

Criteria are µg/l total recoverable

[1]Hardness >50 mg/l and pH>7.0; one hour

[2]Hardness 200 mg/l and pH 7.5; 4 day

[3]Hardness 200 mg/l and pH 8; 4 day

[4]Hardness 400 mg/l and pH 7.5; 4 day

[5]Hardness 400 mg/l and pH 8; 4 day

Table 3. UPDES Permits that EPA (2018) criteria would be less stringent than Utah's current criteria

Permit No.	Hardness	pH	Ecoregion
UT0024210	207	8.0-8.1	13
UT0025992	400	8.2	20
UT0000361	400	8.4	13
UT0000035	400	8.1-8.3	20
UT0025348	400	8.1-8.3	20
UT0024805	400	7.7-7.9	13
UT0020311	400	8.2-8.6	13
UT0025763	168	8.3-8.5	19

Permit No.	Hardness	pH	Ecoregion
UT0022365	200	8.4	13
UT0022616	400	7.5-7.6	20
UT0022918	400	8.2-8.3	19/20
UT0025789	250	8.5	20
UT0025526	202	7.9-8.1	13
UT0023663	400	8	20
UT0021296	400	8-8.1	20
UT0025704	226	8-8.2	13
UT0021911	250	7.7-7.9	13
UT0020931	319	8.2-8.4	13
UT0025828	335	8.1-8.5	20
UT0020095	195	8.2-8.5	20
UT0025801	218	8.2	20
UT0026018	400	8	20
UT0023922	400	8.2	20
UT0025712	400	8.4	20
UT0025283	263	8.1-8.5	13
UT0025984	400	8.1	19
UT0025542	350	8.2-8.7	19
UT0020052	400	7.9-8.4	20
UT00237l8	400	8-8.2	21
UT0026034	400	8.1	13
UT0021130	300	8.5	13
UT0025771	259	8.3-8.4	20
UT0026123	236	8.1-8.3	13

Permit No.	Hardness	pH	Ecoregion
UT0020192	280	8.1-8.5	19
UT0023094	400	8-8.1	20
UT0023205	298	8-8.4	13
UT0025852	380	8.1-8.4	13
UT0022403	300	8	19
UT0025747	390	7.8-7.9	19
UT0020966	176	7.9-8.4	19
UT0020214	217	8.2-8.5	13
UT0025569	400	8.0	13
UT0021920	250	7.8-8.1	13
UT0021440	200	7.8-8	13
UT0026026	400	8.2	19
UT0020419	335	8.5-9	20
UT0000612	300	7.7-7.8	13
UT0025950	200	8	13
UT0024503	300	8-8.2	20
UT0020893	252	8.2-8.5	19
UT0024732	232	7.9-8.5	19
UT0023001	400	8	20
UT0023850	400	7.8-8.3	13
UT0020061	164	7.8-8.2	19
UT0020915	244	7.8	13
UT0025577	300	8.1-8.2	13
UT0023604	243	8.3-8.5	20
UT0000116	400	7.6	13

Permit No.	Hardness	pH	Ecoregion
UT0025623	389	8.1-8.5	13
UT0022896	400	7.5	20
UT0026158	271	8.6	13
UT0020427	390	7.8-8.3	13
UT0020222	309	7.8	13
UT0021814	400	7.4	20
UT0026166	400	7.8-8.0	20
UT0020907	218	8.0-8.2	13
UT0026085	300	8.2	13
UT0020001	340	7.9-8.2	19
UT0024384	350	8-8.4	13
UT0020109	338	7.8-8.1	13
UT0025224	306	8.1-8.3	20
UT0020934	250	8.0-8.3	13
UT0024686	400	7.9	14
UT0024759	400	8.4	20
UT0000281	400	8.2-8.3	13
UT0023639	349	8.6	13
UT0025810	70	7.7-8.3	20
UT0024767	398	7.8-7.9	13
UT0020371	280	7.9-8.3	13
UT0024368	204	8.7	19

Table 4, UPDES Permits that EPA (2018) criteria would be more stringent than the Utah's current criteria

Permit No.	Hardness	pH	Ecoregion
UT0024392	290	7.5-7.8	13
UT0025976	392	7.2-7.9	19
UT0023752	300	7.3-8	19
UT0025429	200	7.5	13
UT0026140	400	7.5	19
UT0025097	300	7.5-7.6	13
UT0025461	400	7.5	19
UT0025518	390	7.5-7.6	13
UT0025097	300	7.5-7.6	13
UT0021717	259	7.2	13
UT0024414	400	7.1-7.2	19
UT0021636	350	7.5-8	13
UT0021628	350	7.5-8	13
UT0025241	400	7.5-7.6	13
UT0020303	250	7.4-7.7	13

Implementation Considerations for Assessments

For assessments, total aluminum concentrations, pH, hardness, and DOC concentrations that are measured at the same time and place will provide the most accurate data for assessments (EPA, 2018). The total aluminum concentrations may be based on an approved EPA analytical method for total recoverable aluminum or a method that better measures the bioavailable fraction of aluminum (EPA, 2019). If an alternative analytical method is to be implemented, the data quality indicators such as precision, accuracy, representativeness, comparability, and completeness should be evaluated consistent with DWQ's *Quality Assurance Program Plan for Environmental Data Operations*.

The determination of whether to estimate the values for missing parameters to support assessments is dependent on the specific goals and purposes of the assessment. Estimated parameters factor values are not currently used in Utah's Integrated Report when measured values are unavailable. These decisions are documented in the assessment methods document.

Recommended Rule Changes

The following strikeout and underlining formats show the proposed changes to Table 2.14.2 in UAC R317-2-14, footnotes (5) and (6). Existing footnote (5) will be changed to (6) to maintain the order of the footnotes in Table 2.14.2. Aluminum will be separated from the existing DISSOLVED criteria and specified as TOTAL RECOVERABLE. Not all of the substances listed under the METALS heading are metals, so the headings METALLOIDS (e.g., arsenic) and DISSOLVED SUBSTANCES (e.g., cyanide) are added. Footnote (4) is unchanged.

The updated criteria will supersede the existing criteria 3 years after the Water Quality Board adopts the updated criteria. The 3-year delay in implementation of the aluminum criteria is intended to provide time for DWQ or dischargers to implement changes in assessment methods and monitoring to support the EPA (2018) aluminum criteria. Unlike other regression-based criteria, the EPA (2018) did not publish the actual equation. EPA (2018) recommends that states adopt the spreadsheet calculator or the tables in Appendix K. DWQ is recommending that the Appendix K tables be incorporated by reference along with a provision that is intended to allow the use of the criteria calculator for water chemistries that are not explicitly included in the tables. Analytical methods are expected to continue to evolve and footnote 6(d) is intended to provide flexibility to select the most appropriate current analytical method for assessments. UPDES permits remain required to the use the specific EPA-approved methods from 40 CFR Part 136 for measuring total recoverable aluminum in effluents.

METALS
(TOTAL RECOVERABLE,
UG/L)
Aluminum (4) (5)

4 Day Average	87	87	87	87
1 Hour Average	750	750	750	750

METALS, METALLOIDS
AND SUBSTANCES (4)
(DISSOLVED, UG/L) (6)
[UG/L)(5)
Aluminum

4 Day Average (6)	87	87	87	87
1 Hour Average	750	750	750	750

]

-----------------------BREAK---------------------------------

(4) Where criteria are listed as 4-day average and 1-hour average concentrations, these concentrations should not be exceeded more often than once every three years on the average.

(5) [The dissolved metals method involves filtration of the sample in the field, acidification of the sample in the field, no digestion process in the laboratory, and analysis by EPA approved laboratory methods for the required detection levels.

(6)]The criterion for aluminum will be implemented as follows:

Until (insert date 3 years after adoption of rule), w[W]here the pH is equal [-]to or greater than 7.0 and the hardness is equal to or greater than 50 ppm as CaCo3 in the receiving water after mixing, the 87 ug/1 chronic criterion (expressed as total recoverable) will not apply, and aluminum will be regulated based on compliance with the 750 ug/1 acute aluminum criterion (expressed as total recoverable).

On and after [insert DATE at least 3 years from Board adoption date], the one-hour and four-day aluminum criteria are incorporated by reference from Appendix K, Recommended Criteria for Various Water Chemistry Conditions, Final Ambient Water Quality Criteria for Aluminum 2018, EPA-822-R-18-001.

(5a) For water chemistry conditions not specifically listed in Appendix K, the criteria are the more stringent of the criteria bracketed by the two most similar water chemistry conditions or may be interpolated using the same equations used to create the Appendix K tables.

(5b) Criteria based on ambient water chemistry conditions must protect the water body over the full range of water chemistry conditions, including during conditions when aluminum is most toxic.

(5c) For characterizing ambient waters, total recoverable analytical methods may be used or different scientifically appropriate analytical methods that measure the bioavailable fraction of aluminum that includes the measurement of amorphous aluminum hydroxide yet minimizes the measurement of mineralized forms of aluminum such as aluminum silicates associated with suspended sediment particles or clays.

(6) The dissolved metals method involves filtration of the sample in the field, acidification of the sample in the field, no digestion process in the laboratory, and analysis by EPA approved laboratory methods for the required detection levels.

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