

Attachment D
December 9, 2010 EQC Meeting



State of Oregon
Department of
Environmental
Quality

Water Quality Standards Review and Recommendations: Iron and Manganese



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This report prepared by:

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Executive Summary

The Department of Environmental Quality (DEQ) proposes to revise Oregon’s human health water quality criteria for iron and manganese as shown in Table 1 below. The proposed criteria, the scientific basis and rationale for the revisions and the process DEQ used to review these criteria are discussed in this issue paper.

Table 1. Proposed Human Health Water Quality Criteria for Iron and Manganese (µg/l)				
Pollutant	Water and Fish Ingestion		Fish Consumption Only	
	Current Criteria	Proposed Criteria	Current Criteria	Proposed Criteria
Iron	300	None	None	None
Manganese	50	None	100	100 Saltwater only

Notes:

- 1) Current criteria are from Table 20 (OAR 340-041-0033).
- 2) The aquatic life criterion for iron is 1000µg/l. There are no aquatic life criteria for arsenic or manganese.
- 3) The fish consumption only criteria are for the total recoverable metal concentrations.

Iron

DEQ reviewed the iron criterion for human health because iron is a naturally occurring earth metal that sometimes exceeds the current criterion due to natural background levels, and because the criterion is not based on levels needed to protect human health. Oregon’s current “human health” criterion for iron is 300 µg/L (0.3 mg/L). This was EPA’s national recommended criterion at the time it was adopted. However, EPA does not consider iron a priority pollutant and did not recommend a criterion for fish consumption. EPA based their recommended criterion on taste and laundry staining effects, not on human health effects.

DEQ proposes to withdraw Oregon’s human health criterion for iron for the following reasons:

- The current criterion of 300 µg/L is not based on human health effects.
- Iron criteria for the protection of human health are not necessary. The amount of iron that people can ingest without adverse effects are higher than those found in Oregon surface waters and much higher than the aquatic life criterion of 1000 µg/L.
- DEQ does not expect that discharges of iron in Oregon will impact beneficial uses, including the ability to drink water or consume fish.
- Oregon has a narrative criterion and EPA has a secondary MCL that allow DEQ or water suppliers to protect against objectionable taste and odor from iron in the water if a community finds there is a need to do that.

These revisions would not affect the current freshwater aquatic life criterion for iron, which is a chronic criterion of 1000 µg/L (1.0 mg/L). Aquatic life is a designated beneficial use in all surface waters of Oregon and therefore the aquatic life criterion for iron applies to all waters.

Manganese

DEQ reviewed the manganese criteria for human health because manganese is a naturally occurring earth metal in Oregon and because the “water and fish ingestion” criterion is based on taste and laundry staining effects, not on levels necessary to protect human health.

DEQ proposes to withdraw the manganese criterion for water and fish ingestion for the following reasons:

- The criterion is not based on human health effects. EPA has not recommended a water and fish ingestion criterion for the protection of human health, nor have they recommended an MCL to protect against human health effects of manganese in drinking water. Manganese levels in Oregon surface waters are far below average daily human intake levels, which are primarily taken in through food.
- There is no reason to conclude that discharges of manganese will impact beneficial uses of Oregon’s fresh waters.
- Oregon does not need a numeric manganese criterion to protect water supply based on aesthetic and organoleptic effects. The Safe Drinking Water Information System database shows only one surface water supplier with detectable levels manganese in their finish water, and the concentration was 0.8 µg/l, far below the levels where aesthetic or taste effects are objectionable (30 – 150 µg/l). DEQ has a narrative criterion for the protection of taste, odor and aesthetic affects should limits be required to protect a surface water domestic water supply source from particularly high levels of manganese from anthropogenic sources. Finally, EPA has a secondary MCL of 50µg/l in place under the Safe Drinking Water Act to provide guidance to water suppliers who would like to prevent these non-health based effects.

In addition, DEQ proposes to withdraw the “fish consumption only” manganese criterion (100 µg/l) as it applies to freshwaters but will leave this criterion in place for saltwater. EPA recommended the 100µg/l criterion in 1976, prior to the fish ingestion/bioconcentration factor derivation method, which was published in 1980. The EPA criterion was not based on a calculation method, but rather was recommended due to concerns about possible high bioconcentration rates among marine mollusks. Data collected since that time show that bioconcentration factors for manganese in freshwater species are low (i.e., manganese does not accumulate in freshwater aquatic species in appreciable amounts). Consequently, a freshwater fish consumption criterion for manganese is not needed.

Arsenic

DEQ reviewed the human health criteria for arsenic, another naturally occurring earth metal, and proposed revisions to the criteria and adoption of an arsenic reduction policy for public comment. Following the public comment period, DEQ decided to take additional time to consider and respond to the comments received. DEQ anticipates recommending revisions to the arsenic criteria to the EQC in the spring of 2011.

Chapter 1 Introduction and Background

The Oregon Department of Environmental Quality (DEQ) reviewed the science behind the human health water quality criteria for some of the naturally occurring earth metals in response to concerns expressed to the Oregon Environmental Quality Commission (EQC) at their meeting in October 2008. Arsenic, iron and manganese are the three metals that DEQ selected to review in more detail. These three earth metals are naturally occurring and are found in Oregon waters at natural background levels greater than the current human health criteria. There are water bodies listed as impaired for all three metals on the 2004/06 303(d) list as in need of TMDLs. In addition, stakeholders point out that the arsenic criteria under the Clean Water Act are much more stringent than the maximum contaminant level for drinking water established under the Safe Drinking Water Act.

At its October 2008 meeting, the EQC directed DEQ to revise Oregon's human health criteria for toxic pollutants based on the recommended increased fish consumption rate of 175 grams per day; the Department is conducting that rulemaking process separately. DEQ moved forward with proposed rules for public comment for these three criteria in advance of the full human health criteria rulemaking for several reasons. First, the timeframe for the larger package targets EQC adoption in mid-2011 and the revised criteria will not likely be effective until late 2011 at the earliest, possibly not until mid-2012 or later. Second, the scientific review and early stakeholder review of these revisions are complete and the proposal was ready for public comment. Third, the changes are significant for several NPDES permits that will be renewed over the next year to 18 months. And lastly, 107 stream segments, which account for 43% of the total stream segments currently listed for toxic pollutants, are listed for arsenic, iron or manganese. If the proposed revisions are adopted by the EQC in late 2010 or early 2011, they should be effective for use in the 2012 water quality assessment. This will help DEQ to target its resources and those of dischargers to address more important environmental improvements.

DEQ worked with a stakeholder workgroup (membership shown below) to develop the proposed criteria revisions and an accompanying arsenic reduction policy. The workgroup supported the proposal. DEQ took public comment on the proposed rules from August 25 to September 30, 2010 and held two public hearings. Following the comment period, DEQ decided to recommend EQC adoption of the iron and manganese criteria revisions in December, 2010. DEQ will take additional time to consider the comment received on the arsenic proposal and anticipates recommending arsenic criteria revisions to the commission in the spring of 2011. For more information on the hearings and the public comment received, see the "Summary of Public Comment and Agency Response" attached to the EQC Staff Report on the proposed amendments to Oregon's iron and manganese water quality criteria for human health.

Table 2. Toxics Standards Rulemaking Workgroup Members (RWG)

Organization	Representative
CTUIR	Ryan Sudbury/Rick George
EPA	Jannine Jennings
ACWA	Dave Kliewer
League of Oregon Cities	Peter Ruffier
Northwest Pulp and Paper	Kathryn Van Natta
Industrial Dischargers	Michael Campbell
Associated Oregon Industries	Rich Garber or alternate Myron Burr
Northwest Environmental Advocates	Nina Bell
Oregon Environmental Council	Andrew Hawley
Columbia Riverkeeper	Lauren Goldberg

Chapter 2. Iron Human Health Criteria Review and Recommendations

As part of the review of Oregon's human health toxics criteria, DEQ re-evaluated the human health criterion for iron. DEQ reviewed this criterion because iron is a naturally occurring earth metal that sometimes exceeds the criterion and because the current criterion is not based on levels needed to protect human health.

Oregon's Current Iron Criteria

Oregon's current water quality criteria for iron include a "water and fish ingestion" criterion of 300 µg/l (0.3 mg/l) for human health and a chronic criterion of 1000 µg/l (1.0 mg/l) for freshwater aquatic life. These were EPA's national recommended criteria in the late 1980's when DEQ adopted these values.

Federal Requirements and Recommendations

Iron is a "non-priority" pollutant under the CWA. Federal regulations for non-priority pollutants (40 CFR § 131.11) require that states adopt criteria based on a sound scientific rationale that covers sufficient parameters to protect designated uses. Both numeric and narrative criteria may be applied to meet these requirements (EPA, 1994).

EPA's 1976 and 1986 *Quality Criteria for Water* (referred to as the "Red Book" and "Gold Book," respectively) established 300 µg/l as the recommended water quality criterion for iron for protection of domestic water supplies (EPA, 1976; EPA, 1986). According to the Red Book, "the iron criterion in water is to prevent objectionable tastes or laundry staining (0.3 mg/l) [and] constitutes only a small fraction of the iron normally consumed and is of aesthetic rather than toxicological significance" (text in brackets added). EPA previously recommended in *Water Quality Criteria 1972* (EPA, 1973) that 0.3 mg/l soluble iron not be exceeded in public water supply sources.

EPA's human health iron criterion under the Clean Water Act is the same as the secondary maximum contaminant level (MCL) established in EPA's National Secondary Drinking Water Regulations under the Safe Drinking Water Act. Secondary MCLs are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. The contaminants are not considered to present a risk to human health at the secondary MCL level (EPA, 1992b).

Effects of Iron related to Public Water Supply

Taste. There is a range of sensitivities to the taste of iron in drinking water that can vary based on the form of iron. A 1960 study referenced by EPA's "Red Book" (1976) indicated that the taste of iron may be detected readily at levels of 1800 µg/l in spring water and 3400 µg/l in distilled water.

Health. The “Red Book” also noted that the daily nutritional requirement for iron is 1000 to 2000 µg/l, but that much larger amounts of iron must be ingested due to poor absorption. Tolerable upper intake levels used for a recent revision to West Virginia’s criterion were 45,000 µg/l for adults and 40,000 µg/l for children.

Recent Actions in other States

As part of this review, DEQ considered information summarized here about iron criteria revisions that have been conducted in other states.

West Virginia: In 2003, the State of West Virginia adopted an iron criterion of 1500 µg/l for the protection of both aquatic life and human health uses. Support for EPA approval included the following:

- EPA Region 3 had previously approved a 1500 µg/l iron criterion for Pennsylvania, citing scientific studies that demonstrate that an aquatic life criterion of 1500 µg/l for total iron is sufficiently protective of both instream and withdrawal uses of Pennsylvania’s waters.
- EPA Region 8 has approved site-specific iron criteria greater than 1000 µg/l based on scientific site-specific studies in Colorado.
- EPA’s national recommended water quality criterion for iron of 300 µg/l is based on national secondary drinking water standards, which are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor.
- Tolerable Upper Intake Levels (UL) of iron for adults is 45 mg (45,000 µg) per day and for children is 40 mg (40,000 µg) per day. Maximum average intake from food and supplements is about 18 mg (18,000 µg) per day.
- Human health iron toxicity studies indicate that 1500 µg/l is protective of the majority of the population.

Missouri: In 2006, the State of Missouri removed its drinking water criterion of 300 µg/l for iron. Support for EPA approval included the following:

- EPA’s recommended criterion for iron of 300 µg/l is based on aesthetic (e.g., laundry staining) and organoleptic (i.e. taste) effects and as such, was not developed to protect against toxicological effects.
- EPA reviewed data provided by the Missouri Department of Natural Resources regarding the State’s 2002 and draft 2004 lists of impaired waters. Based upon this information, EPA did not have reason to expect levels of iron to be present that would interfere with the protection of waters designated for Drinking Water Supply.
- The manner in which Missouri assigns designated uses to the state’s waters results in any water designated for Drinking Water Supply to also be designated for Warm Water Aquatic Life and Human Health-Fish Consumption. Given this method, the chronic aquatic life criterion for iron of 1000 µg/l, expressed as dissolved iron, is effective for all waters designated as Drinking Water Supplies.
- EPA also reviewed available information regarding potential human health effects from iron and analyzed this information, in combination with water quality monitoring data

from waters in Missouri designated as Drinking Water Supply, in order to estimate potential exposure to iron. The results of this analysis led EPA to determine that the absence of an iron criterion for drinking water would not result in significant increased exposure to iron, and that a separate criterion for iron is not necessary to protect Missouri's Drinking Water Supply Use.

DEQ Proposed Revision

DEQ proposes to withdraw Oregon's human health criterion for iron for the following reasons:

- The current criterion of 300 µg/l is not based on human health effects.
- Iron criteria for the protection of human health are not necessary. The levels of iron that may be consumed without adverse health effects are much higher than the levels found in Oregon surface waters and much higher than the aquatic life criterion of 1000 µg/l.
- DEQ does not expect that discharges of iron in Oregon will impact beneficial uses, including the ability to drink water or consume fish.
- Oregon has a narrative criterion that allows us to protect against objectionable taste and odor if there is a need to do so.

Table 3 below shows iron data for the Willamette River at the St. John's Bridge, just below the city of Portland. These values are well below levels that are unsafe for human consumption.

The proposed revision would not affect the current freshwater aquatic life criterion for iron, which is a chronic criterion of 1000 µg/L (1.0 mg/L). Aquatic life is a designated beneficial use in all surface waters of Oregon and therefore the aquatic life criterion for iron applies to all waters.

DEQ's Toxics Standards Review Rulemaking Workgroup, a group of stakeholders providing input to DEQ on this rulemaking, supports the proposed criteria changes for iron.

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Table 3. Water column iron data for the Willamette River below Portland (at St. Johns RR bridge) from Portland Bureau of Environmental Services, from 3/04 to 12/07

Dissolved Iron, µg/l

Result	Method	MDL
25.9	EPA 200.8	10.0
18.1	EPA 200.8	10.0
44.8	EPA 200.8	10.0
39.8	EPA 200.8	10.0
33.6	EPA 200.8	10.0
43.7	EPA 200.8	10.0
47	EPA 200.8	10.0
32.6	EPA 200.8	10.0
25.3	EPA 200.8	10.0
63.7	EPA 200.8	10.0
188	EPA 200.8	10.0
34.6	EPA 200.8	10.0
25.3	EPA 200.8	10.0

Total Iron, µg/l

Result	Method	MDL
225	EPA 200.8	10.0
243	EPA 200.8	10.0
375	EPA 200.8	10.0
288	EPA 200.8	10.0
422	EPA 200.8	10.0
734	EPA 200.8	10.0
1060	EPA 200.8	10.0
221	EPA 200.8	10.0
269	EPA 200.8	10.0
3890	EPA 200.8	10.0
1310	EPA 200.8	10.0
203	EPA 200.8	10.0
244	EPA 200.8	10.0

Chapter 3. Manganese Human Health Criteria Review and Recommendations

As part of the review of Oregon's human health toxics criteria, DEQ reevaluated the human health criteria for manganese. DEQ reviewed these criteria because manganese is a naturally occurring earth metal in Oregon that sometimes exceeds the "water and fish ingestion" criterion and because that criterion for "water and fish ingestion" is not based on levels needed to protect human health.

Background Information

According to the World Health Organization (1999), manganese (Mn) is a naturally occurring element that is found in rock, soil, water and food. All humans are exposed to manganese, and it is a normal component of the human body. Food is usually the most important route of exposure for humans. (See the Appendix B for more information from the WHO document.)

Studies of manganese concentrations in soils found that they generally range from 200 to 1000 $\mu\text{g/g}$ in volcanically derived soils (Alloway, 1990 in DEQ, 2008). Natural background manganese concentrations in Washington State soils average between 700 and 1500 $\mu\text{g/g}$ (Juan, 1994 in DEQ, 2008). Sampling by DEQ and USGS in the Molalla-Pudding subbasin of Oregon showed dissolved manganese concentrations in groundwater ranged from $< 1 \mu\text{g/l}$ to 740 $\mu\text{g/l}$ (DEQ, 2008).

Figure 1 shows surface water data for dissolved manganese from DEQ's LASAR database. Out of over 7000 samples, less than a handful exceed 1000 $\mu\text{g/l}$ and only a small portion exceed 200 $\mu\text{g/l}$ dissolved manganese. DEQ's 303(d) list includes 26 water bodies as exceeding the current "water and fish ingestion" criterion of 50 $\mu\text{g/l}$ (Table 7). Figure 2 shows seasonal dissolved manganese data from Beaverton Creek, Oregon. Manganese concentrations increased through the spring and summer, peaking in late summer/early fall and dropping for late fall and winter. This suggests that concentrations are higher relative to low base flows, which typically include a larger portion of groundwater inflow, and reduced relative to surface water runoff that occurs in response to rainfall events.

Oregon's Current Human Health Criteria for Manganese

Oregon's currently effective CWA criteria for manganese, which apply to both fresh and marine waters, are:

- 50 $\mu\text{g/l}$ dissolved manganese for "human health, water and fish ingestion," and
- 100 $\mu\text{g/l}$ total manganese for "human health, fish consumption only. "

These were EPA's nationally recommended criteria at the time they were adopted.

Federal Criteria Requirements and Recommendations

Manganese is considered a “non-priority” pollutant by EPA. 40 CFR § 131.11 describes the federal criteria requirements applicable to non-priority pollutants. Under these requirements, states must adopt criteria based on sound scientific rationale that cover sufficient parameters to protect designated uses. Both numeric and narrative criteria may be applied to meet these requirements (EPA, 1994).

Protection of domestic water supply. EPA’s 1976 and 1986 *Quality Criteria for Water* (referred to as the “Red Book” and “Gold Book,” respectively) established 50 µg/l as the recommended water quality criterion for manganese for protection of domestic water supplies. This criterion was established to protect against objectionable tastes and laundry staining. The Red Book provides that, “a criterion for domestic water supplies of 50 µg/l [for manganese] should minimize the objectionable qualities” (text in brackets added). EPA’s recommendation for manganese in Water Quality Criteria 1972 (EPA, 1973) specified that 0.05 mg/l (50 µ/l) soluble manganese not be exceeded in public water sources based on user preference. One study found that consumer complaints about brownish staining of laundry and objectionable tastes in beverages arise when manganese exceeds 150 µg/l (Griffin, 1960 in EPA Red Book). The Red Book also notes that manganese concentrations of 10 to 20 µg/l are acceptable to most consumers.

The manganese criterion of 50 µg/l for protection of domestic water supply uses that EPA recommends under the Clean Water Act is the same as the secondary maximum contaminant level (MCL) established by EPA in their National Secondary Drinking Water Regulations under the Safe Drinking Water Act. Secondary MCLs are established as guidelines to assist public water systems manage their drinking water for aesthetic considerations, such as taste, color and odor. These contaminants are not considered to present a risk to human health at the secondary MCL (EPA, 1992).

EPA has not recommended a manganese criterion for the protection of human health in fresh waters. Manganese is a vital micro-nutrient (EPA, 1976). EPA notes that the average human intake is approximately 10 mg/day (10,000 µg/day) and that while very large doses of ingested manganese can cause some disease and liver damage; these are not known to occur in the United States. Additional information on human intake levels from the World Health Organization is provided in Appendix B.

Protection of Consumers of Marine Mollusks. While EPA’s criteria documents (1976, 1986) conclude that “manganese is not considered to be a problem in fresh waters,” they do establish a recommended human health criterion for manganese of 100 µg/l for the protection of consumers of marine mollusks. The following information is provided in the 1976 criteria document:

- The average human intake of manganese is approximately 10 mg (10,000 µg) per day.
- Very large doses of ingested manganese can cause some disease and liver damage but these are not known to occur in the United States.
- The ambient [marine] concentration of manganese is about 2 µg/l (Fairbridge, 1966). The material is rapidly assimilated and bioconcentrated into nodules that are deposited on

the sea floor. The major problem with manganese may be concentration in the edible portions of mollusks, as bioaccumulation factors as high as 12,000 have been reported (NAS, 1974 in EPA, 1976). In order to protect against a possible health hazard to humans by manganese accumulation in shellfish, a criterion of 100 µg/l is recommended for marine water.

More recent bioconcentration data from EPA's ECOTOX database shows that while marine mollusks have higher bioconcentration factors than other species, the BCFs range from 677 to 2583, with 47 of the 53 BCFs being above 1000 (see Table 5).

EPA's 2002 national criteria recommendations still include the 1976 "organism only" criterion for manganese of 100µg/l as a non-priority pollutant due to potential human health concerns related to consuming oysters and other marine mollusks. Oysters and other marine mollusks occur in "saltwater." In their 2002 criteria document, EPA defines "saltwater" v. "freshwater" for the purpose of applying the aquatic life criteria based on the species that would be present dependent on salinity levels.

Recent Actions in other States

In 2006, the State of Missouri removed its drinking water criterion of 50 µg/l for manganese. Support for EPA approval included the following:

- EPA's recommended criterion for manganese of 50 µg/l is based on aesthetic (e.g., laundry staining) and organoleptic (i.e., taste) effects, and was not developed to protect against toxicological effects.
- EPA reviewed available information regarding potential human health effects from manganese and analyzed this information, in combination with water quality monitoring data from waters in Missouri, in order to estimate potential exposure to manganese. The results of this analysis led EPA to conclude that the current levels of manganese in Missouri's waters pose no long-term risk to human health and that a numeric criterion for manganese is not necessary to ensure protection of Missouri's Drinking Water Supply designated use. EPA concluded that the Missouri Department of Natural Resource's remaining revised numeric metals criteria and narrative criteria protect the designated use.

DEQ Proposed Revisions to Oregon's Manganese Human Health Criteria

Water and fish ingestion criterion. DEQ proposes to withdraw Oregon's manganese criterion for water and fish ingestion. This criterion was not based on health effects. EPA has not recommended a water and fish ingestion criterion for the protection of human health, nor have they recommended an MCL to protect against human health effects of manganese in drinking water. Manganese levels in Oregon surface waters are far below average daily human intake levels (see Figure 1). There is no reason to believe that discharges of manganese will impact beneficial uses of drinking water or fish consumption for Oregon's fresh waters.

In addition, Oregon does not need a numeric manganese criterion to protect water supply based on aesthetic and organoleptic effects. Table 6 below shows that only one surface water supplier detected manganese in their finish water and the concentration was 0.8 µg/l, far below the levels where aesthetic or taste effects are objectionable (30 – 150 µg/l). In addition, DEQ has a narrative criterion for the protection of taste, odor and aesthetic affects should limits be required to protect a surface water domestic water supply source from particularly high levels of manganese from anthropogenic sources. Finally, EPA has a secondary MCL of 50µg/l in place under the Safe Drinking Water Act to provide guidance to water suppliers for these non-health effects.

Fish consumption only criterion. DEQ proposes to withdraw the 100 µg/l “fish consumption only” criterion as it applies to freshwater, but leave the criterion in place as it applies to saltwater. The 100µg/l criterion was recommended by EPA in 1976, prior to the 1980 publication of their method to develop criteria based on bioconcentration. However, EPA recommended this criterion due to concerns about high bioconcentration rates among marine mollusks (oysters). A fish consumption criterion for freshwaters is not needed because BCFs for manganese in freshwater species are low.

DEQ does not propose to revise the manganese criterion as it applies to the consumption of marine mollusks and did not conduct a review of the scientific literature for that purpose. Rather, DEQ proposes to leave the Oregon’s current “fish consumption only criterion” in place for application to saltwater in order to protect for the consumption of marine mollusks, such as oysters. This criterion also remains EPA’s recommended criterion. DEQ intends to use the definition of saltwater provided by EPA in their 2002 national criteria recommendations to indicate the presence of marine mollusks. Saltwater is defined based on salinity concentrations and can include estuarine as well as marine waters. Because the criterion is not based on a fish ingestion/ bioconcentration methodology, it will not be revised based on Oregon’s revised fish consumption rate.

Additional options considered for the “fish consumption only” criterion were to:

- Retain the 100ug/l criterion with 2004 clarification that it will be applied as a dissolved concentration,
- Revise the 100 µg/l manganese criterion
- Withdraw the criterion, demonstrating that it is not needed to protect the applicable designated use in Oregon.

DEQ’s Toxics Standards Review Rulemaking Workgroup, which is a group of stakeholders providing input to DEQ on this rulemaking, supported the recommendations below at their meeting on July 13, 2009.

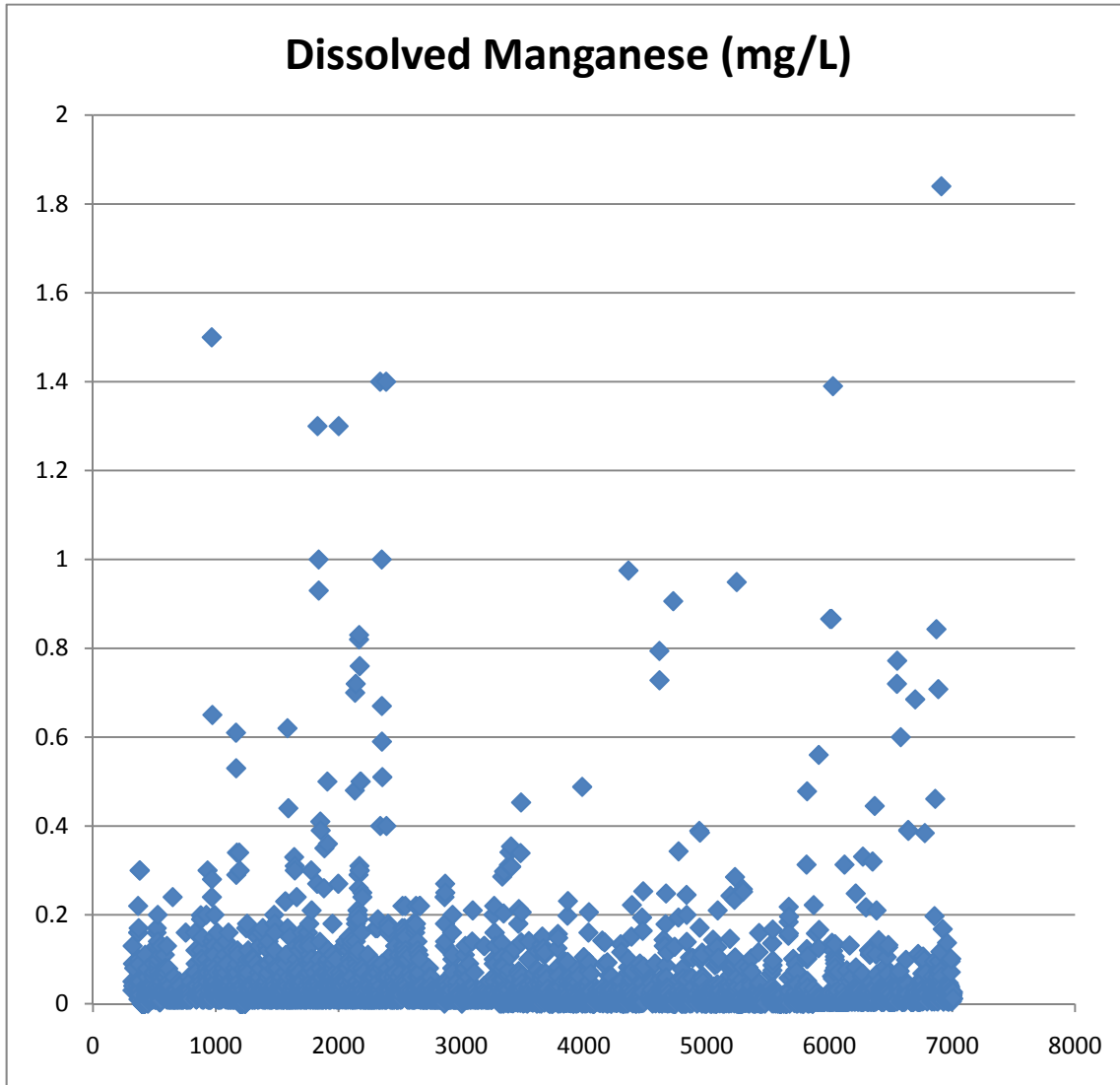


Figure 1. Surface water data for freshwaters of Oregon. From DEQ LASAR data base.
Note: 0.2 mg/l = 200 µg/l.

Table 4. Manganese Listings from DEQ's 2004/06 303d Assessment, based on Table 20 Criteria

Watershed (USGS 4th Field Name)	Water Body (Stream/Lake)	River Miles	Samples exceeding
COOS	Isthmus Slough	0 to 10.6	2 of 2
CROSSES SUBBASINS	Willamette River	0 to 24.8	7 of 175
CROSSES SUBBASINS	Willamette River	119.7 to 148.8	2 of 84
CROSSES SUBBASINS	Willamette River	148.8 to 184.7	7 of 313
DONNER UND BLITZEN	Bridge Creek	0 to 3.1	4 of 4
Lower Columbia	Unnamed Creek	0 to 3.2	4 of 5
LOWER OWYHEE	Overstreet Drain	0 to 0	2 of 3
LOWER WILLAMETTE	Arata Creek / Blue Lake	0 to 0.9	7 of 25
LOWER WILLAMETTE	Columbia Slough	0 to 8.5	7 of 8
LOWER WILLAMETTE	Columbia Slough	0 to 9.8	45 of 61
LOWER WILLAMETTE	South Columbia Slough	0 to 3.2	4 of 7
MCKENZIE	Blue River	0 to 15.5	2 of 38
MIDDLE COLUMBIA-HOOD	Lenz Creek	0 to 1.5	15 of 31
MIDDLE COLUMBIA-HOOD	Neal Creek	0 to 6	0 of 13
MOLALLA-PUDDING	Pudding River	0 to 35.4	7 of 72
MOLALLA-PUDDING	Zollner Creek	0 to 7.8	2 of 2
NORTH UMPQUA	Sutherlin Creek	0 to 16	20 of 26
SOUTH UMPQUA	Middle Creek	0 to 12.8	5 of 13
SOUTH UMPQUA	South Fork Middle Creek	0 to 4.4	8 of 12
TUALATIN	Beaverton Creek	0 to 9.8	64 of 68
TUALATIN	Tualatin River	0 to 80.8	151 of 275
UMATILLA	Umatilla River	0 to 32.1	11 of 50
UMATILLA	Wildhorse Creek	0 to 33.2	
UMPQUA	Cook Creek	0 to 2.9	
UPPER WILLAMETTE	Calapooia River	0 to 42.8	9 of 39
UPPER WILLAMETTE	Long Tom River	0 to 57.3	2 of 34
UPPER WILLAMETTE	Marys River	0 to 41.1	4 of 39
YAMHILL	North Yamhill River	0 to 32.5	3 of 63
YAMHILL	Salt Creek	0 to 32.8	2 of 2
YAMHILL	Yamhill River	0 to 11.2	3 of 67

Figure 2. Seasonal Distribution of Dissolved Manganese ($\mu\text{g/l}$)
 Beaverton Creek Near Orenco USGS and DEQ Data

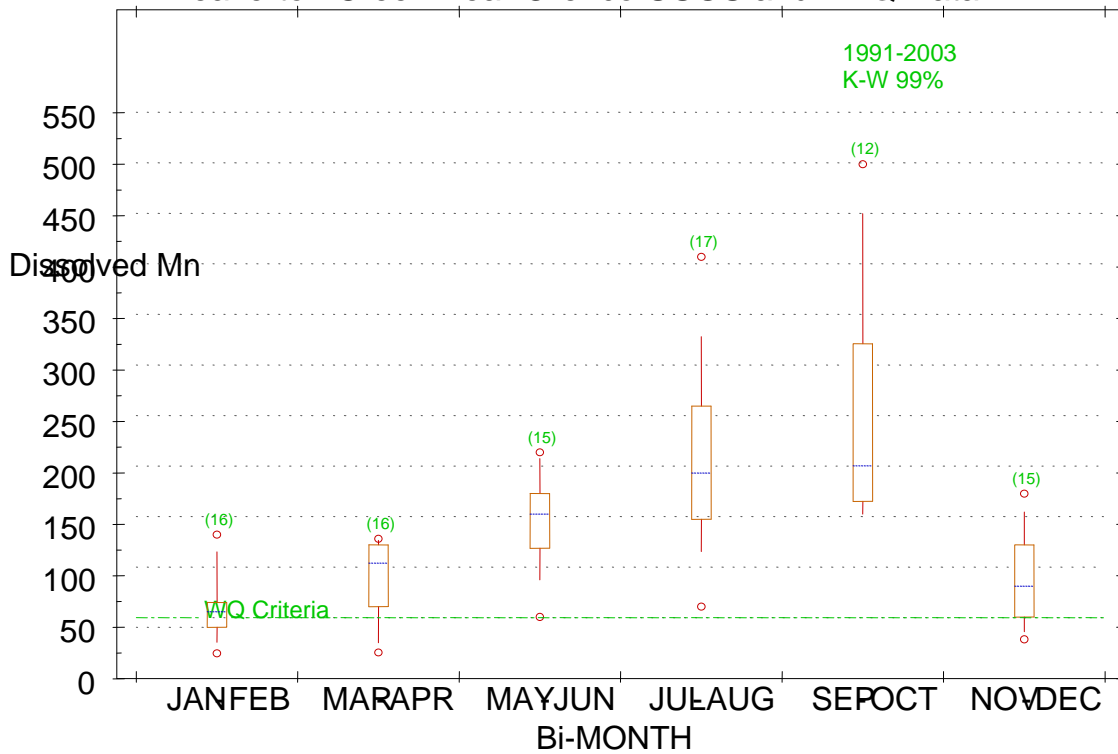


Table 5. Summary of Manganese BCFs for Organisms in Saltwater and Freshwater

Media	Species Group	Number of BCFs	Range of BCF Values		Notes
			Min	Max	
Freshwater	Crustaceans	1	65	65	
Freshwater	Fish	5	0.2	220	
Freshwater	Worms	2	8.5	9	
Saltwater	Crustaceans	14	0	3.18	
Saltwater	Fish	23	10	9090	Only 5 of 23 BCFs were above 1000
Saltwater	Invertebrates	8	3	61	
Saltwater	Mollusks	53	677	2683	47 of 53 BCFs were above 1000
Saltwater	Worms	17	2.2	45	

Values above 1000 considered high bioconcentration potential by EPA R6.
 From "ECOTOX" database, EPA. <http://cfpub.epa.gov/ecotox/>

Table 6. Finish Water Data for Drinking Water Sources, Oregon.

This table contains drinking water source finish data that exceeded detection limits for manganese. Please note that one sample is a surface water source and the other two are groundwater sources. Finish water is water that has undergone standard drinking water treatment.

Finish Water Data for Drinking Water Sources				Manganese µg/l
SW	NPS OREGON CAVES NATL MON	EP FOR LAKE CREEK	24-May-06	0.8
GW	SUNRIVER WATER LLC	~EP FOR WELL 12 (SERVES CROSSWATERS)	13-Sep-06	93
GW	CURRY CO PKS LOBSTER CREEK	EP FOR LOBSTER CREEK	11-Sep-03	58
From: Oregon's Safe Drinking Water Information System (DEQ, 2009)				

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Attachment D
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Appendix A. Supplemental Information on Manganese

World Health Organization, Geneva, 1999. Concise International Chemical Assessment Document 12: Manganese and its Compounds.
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Manganese (Mn) is a naturally occurring element that is found in rock, soil, water, and food. Thus, all humans are exposed to manganese, and it is a normal component of the human body. Food is usually the most important route of exposure for humans. The Food and Nutrition Board of the US National Research Council establishes Estimated Safe and Adequate Daily Dietary Intake (ESADDI) levels, which generally parallel amounts of the compound usually delivered via the diet, although some individuals consume greater or smaller amounts. The ESADDI levels for manganese are 0.3-0.6 mg/day for infants up to 6 months old, 0.6-1.0 mg/day for infants 6 months to 1 year old, 1.0-1.5 mg/day for children 1-3 years old, 1.0-2.0 mg/day for children 4-10 years old, and 2.0-5.0 mg/day for people over 10 years old (NRC, 1989).

In considering development of a guidance value for oral intake of manganese, it must be noted that there is wide variability in human intake of manganese (from all sources) and that manganese is an essential nutrient for humans and animals. Daily manganese intake from food is estimated to be about 2-9 mg for adults, with an absorbed amount of about 100-450 µg/day based upon 5% gastrointestinal absorption (WHO, 1981). Some studies have reported that neurological effects may be related to ingestion of manganese in non-worker populations. However, these reports provide little information on the levels of ingested manganese that were associated with these effects. Although neurological effects might be a potential concern for people working or living at or near sites where ingestion or inhalation of high levels of manganese can occur (see section 9.2), no firm conclusion on a guidance value level for oral intake of manganese other than estimated daily intake levels is considered possible.

More recently, Kondakis et al. (1989) reported that chronic intake of drinking-water containing elevated levels of manganese (1.8-2.3 mg/litre) led to an increased prevalence of neurological signs in elderly residents (average age 67 years) of two small towns in Greece. The effects were compared with those in similarly aged residents in two other communities where manganese levels were within ambient range (0.004 and 0.0015 mg/litre). The findings suggested that above-average oral exposure to manganese might be of health concern. However, although the comparison populations were reportedly very similar to each other, differences in age, occupational exposures, or general health status could have accounted for the small differences observed. Similarly, Goldsmith et al. (1990) investigated a cluster of Parkinson's disease in southern Israel. The authors suggested that excess levels of aluminum, iron, and manganese in the drinking-water and the use of agricultural chemicals, including maneb and paraquat, in the area were common environmental factors that may have contributed to the observed cluster. However, the observed symptoms could not be conclusively attributed to manganese poisoning alone. By contrast, a recent study by Vieregge et al. (1995) on the neurological impacts of chronic

oral intake of manganese in well-water found no significant differences between exposed and control populations in northern Germany. A group of 41 subjects exposed to 0.300-160 mg manganese/litre in well-water was compared with a control group of 71 subjects (matched for age, sex, nutritional habits, and drug intake) exposed to a maximum manganese concentration in well-water of 0.050 mg/litre. Neurological assessments revealed no significant difference between the two groups. Although the effects reported by Kondakis et al. (1989) and Goldsmith et al. (1990) are consistent with the known toxicological effects of manganese, the findings are inconclusive and are contradicted by the results of Vieregge et al. (1995). As a result, no firm conclusions on manganese-induced neurological effects in humans from chronic oral intake of manganese in drinking-water can be made at this time.

In considering development of a guidance value for oral intake of manganese, it must be noted that there is wide variability in human intake of manganese (from all sources) and that manganese is an essential nutrient for humans and animals. Daily manganese intake from food is estimated to be about 2-9 mg for adults, with an absorbed amount of about 100-450 µg/day based upon 5% gastrointestinal absorption (WHO, 1981). Some studies have reported that neurological effects may be related to ingestion of manganese in non-worker populations. However, these reports provide little information on the levels of ingested manganese that were associated with these effects. Although neurological effects might be a potential concern for people working or living at or near sites where ingestion or inhalation of high levels of manganese can occur (see section 9.2), no firm conclusion on a guidance value level for oral intake of manganese other than estimated daily intake levels is considered possible.

Table A-1. Manganese concentrations in selected foods. ^a

Type of food	Range of mean concentrations (ppm; µg/g or mg/litre)
Nuts and nut products	18.21-46.83
Grains and grain products	0.42-40.70
Legumes	2.24-6.73
Fruits	0.20-10.38
Fruit juices and drinks	0.05-11.47
Vegetables and vegetable products	0.42-6.64
Desserts	0.04-7.98
Infant foods	0.17-4.83
Meat, poultry, fish, and eggs	0.10-3.99
Mixed dishes	0.69-2.98
Condiments, fats, and sweeteners	0.04-1.45
Beverages (including tea)	0.00-2.09
Soups	0.19-0.65
Milk and milk products	0.02-0.49

^a Adapted from Pennington et al. (1986).

Table A-2: Summary of typical human exposure to manganese.^a

Parameter	Exposure Medium		
	Water	Air	Food
Typical concentration in medium	4 µg/litre	0.023 µg/m ³	1.28 µg/calorie
Assumed daily intake of medium by 70-kg adult	2 litres	20 m ³	3000 calories
Estimated average daily intake by 70-kg adult	8 µg	0.46 µg ^b	3800 µg
Assumed absorption fraction	0.03 ^c	1 ^c	0.03 ^d
Approximate absorbed dose	0.24 µg	0.46 µg	114 µg

^a Adapted from US EPA (1984).

^b Assumes 100% deposition in the lungs.

^c No data; assumed value.

^d Davidson et al. (1988)