6. WATER TREATMENT

6.1 General Water Quality Considerations

Federal drinking water regulations cover five broad categories of contaminants:

Inorganic chemicals
Radionuclides
Volatile and synthetic organic chemicals
Microbiology and turbidity
Secondary contaminants

Secondary drinking water standards are not federally enforced. Secondary contaminants affect the esthetics of drinking water and, therefore, public acceptance. Color, odor and other undesirable characteristics of water may be affected by the secondary contaminants, but there are no known impacts on health.

All other inorganics, radionuclides, volatile and synthetic organic chemicals and microbiological contaminants are *primary* contaminants, and drinking water standards are enforceable. Maximum contaminant levels (MCL's) have been established or will be established by EPA for the primary drinking water contaminants. The MCL's have been set at levels to ensure that the health of the general population is not adversely impacted by ingestion of water. If contaminants in drinking water exceed the MCL's, a risk of adverse health effects is suspected. The degree of risk associated with some MCL's will be addressed in the sections that follow.

The National Academy of Sciences undertook considerable investigation of drinking water standards following enactment of the Safe Drinking Water Act of 1974 (PL 93-523). The Act directed the Administrator of the Environmental Protection Agency to arrange with the National Academy of Sciences or other appropriate organizations to study the adverse effects of health attributable to contaminants in drinking water.[1] According to the National Academy of Sciences:

> *The primary purpose of the study was to assess the significance of adverse effects that the constituents of drinking water may have on public health. The economic or technological feasibility of controlling the concentrations of these constituents was outside the scope of the study ... The purpose of drinking-water standards is to insure protection from acute poisoning and from long-term 'chronic' effects.*[2]

[1]NAS 1977, p.9

[2]NAS 1977, pp 10 and 22.

Safe Drinking Water Act Amendments were approved by Congress in the Act of June 19, 1986. Directives from Congress to EPA in the 1986 Amendments were as follows:

EPA must set Maximum Contaminant Level Goals (MCLG's) and National Primary Drinking Water Regulations (NPDWR's) for 83 specific contaminants and for any other contaminant in drinking water that may have adverse effect upon the health of persons and which is known or anticipated to occur in public water systems.

MCLG's are non-enforceable health goals that ought to be set at levels at which no known or anticipated health effects occur and which allow an adequate margin of safety.

Maximum Contaminant Levels (MCLs) must be set as close to MCLGs as is feasible. ...

Feasible means with the use of the best technology, treatment techniques and other means, which the Administrator finds, after examination for efficacy under field conditions and not solely under laboratory conditions, are available (taking costs into consideration). ...

MCLGs and MCLs must be proposed at the same time and also promulgated simultaneously.

MCLGs, NPDWRs and monitoring requirements are to be set for 83 contaminants listed in SDWA. NPDWRs can be either MCLs or treatment technique requirements. The Best Available Technology (BAT) is also to be specified for each contaminant for which an MCL is established. ...[3]

This section addresses present and future water quality considerations within the service area of the regional project. A full discussion of existing and proposed regulations pursuant to the Safe Drinking Water Act, as amended, is not provided, but the subjects most relevant to the region are provided. A full list of existing national primary drinking water regulations is provided for reference as Exhibit A at the end of this chapter. Future regulations relating to arsenic, disinfection byproducts, sulfate, and groundwater are addressed in this section.

Table 6-1 summarizes selected secondary contaminants that are unregulated but impact the acceptability and cost of water for drinking and other purposes by users in public water systems of the region. Secondary contaminants include hardness, total dissolve solids (TDS), specific conductance (SC), iron and manganese.

Table 6-1 similarly summarizes selected primary, regulated contaminants and observations of levels of those contaminants in the public water systems of the region. The primary contaminants are regulated to minimize the risks to human health. The primary contaminants

[3]EPA, May 17,1990, p.1.

TABLE 6-1

SELECTED WATER QUALITY PARAMETERS AND OBSERVATIONS

	Secondary Contaminants						Primary Contaminants					
Place/Rural	Place Population	Hardness (mg/l)	TDS (mg/l)	SC µmho/cm	Iron (mg/l)	Manganese (mg/l)	Arsenic (µg/l)	Total Nitrogen (mg/l)	Gross Alpha (pCi/l)	Sulfate (mg/l)	Copper (mg/l)	Lead (mg/l)
Standard	–	250	500	746	0.3	0.05	10	10	15	400	1.3	0.015
Missouri River	–	200	425	634	<.01	<.005	9.97	<.01	–	93	–	–
Place												
Bainville	146	250	–	–	–	–	0.14	–	–		–	–
Brockton	368	250	748	–	0.47	0.3	0	2.49	ND	212	–	–
Culbertson	780	238	–	–	–	–	0	ND	–		–	–
Flaxville	77	250	–	–	–	–	3.71	–	–		–	–
Frazer	401	–	1,180	–	0.52	0.72	–	0.86	–	498	–	–
Froid	230	645	–	–	–	–	0.16	–	ND		–	–
Glasgow	3,574	250	–	–	–	–	0.003	–	ND		–	–
Medicine Lake	362	816	2,200	–	0.56	2.37	7	0.42	1	650	–	–
Nashua	371	706	–	–	–	–	1.16	–	ND		–	–
Opheim	141	250	–	–	–	–	4.09	–	–		–	–
Outlook	113	377	1,043	–	–	–	0.7	1.01	ND	450	–	–
Plentywood	2,119	711	1,150	–	–	–	23	0	ND	377	–	–
Poplar	878	250	1,380	1,629	1.77	0.59	3	0	ND	430	4.28	0.017
Scobey	1,160	286	–	–	–	–	7	–	3.8	373	–	–
Westby	265	566	–	1,773	0.54	0.475	17	1.28	ND	633	–	–
Wolf Point	2,881	310	–	1,582	–	–	0.97	0.73	ND	278	0.25	0.005
	13,866											
Not Place												
Whitetail	--		–	–	–	–	–	–	–		–	–
Peerless	--		–	–	–	–	–	–	–		–	–
Oswego	--		–	–	–	–	–	–	–		–	–
Fort Kipp	--		2,730	–	0.56	0.12	–	<.05	–	1,120	–	–
Raymond	--		–	–	–	–	–	–	–		–	–
Antelope	--		–	1,352	0.3	0.115	0	0	–	335	0.13	0.015
St. Marie	--		–	–	–	–	–	–	–		–	–
	--		–	–	–	–	–	–	–		–	–

included in the tabulation (and the discussion that follows) are those contaminants that have relevance in the region because they are present in at least some systems at levels that cause concern under either existing or proposed regulations. Those primary contaminants are arsenic, total nitrates and nitrites, gross alpha, sulfate, copper and lead. Copper and lead are generally due to in-house and distribution piping of the same material and are not discussed further here.

Volatile and synthetic organic compounds are not included in this examination of water quality observations for the reason that they are not of concern, with the exception of the discovery of dinoseb in the public water system for Opheim, a matter that has been addressed and is being corrected by the public water system. In other systems Sanitary Survey reports and regular monitoring disclose that most volatile and synthetic organic compounds are not detectable.

Microbiological contamination (Section 6.4) is not summarized in Table 6-1 but is the most common source of violation of water quality standards in the public water systems of the region. Measurements of microbiological activity exceed acceptable levels from time to time in some communities but have always been addressed by the communities through disinfection before regulatory agencies ordered action to require households to boil water.

6.2 Secondary Contaminants

6.2.1 Hardness

Table 6-1 presents the secondary hardness standard of 250 milligrams per liter (mg/l) and comparison with the average for the Missouri River of 200 mg/l. Observed levels of hardness in the public water systems of the region range from 238 mg/l (Culbertson) to 816 mg/l (Medicine Lake). Hardness is generally treated with water softening, which constitutes a cost to the consumer. Hardness shortens the lives of water fixtures, such as water heaters and faucets. The cost impact of hardness on the communities of the region is further presented in Chapter 11.

6.2.2 Total Dissolved Solids

Total dissolved solids is a basic measure of drinking water quality. Total dissolved solids (TDS) in water is comprised of inorganic salts and small amounts of organic matter. Principle ions contributing to TDS are carbonate, bicarbonate, chloride, sulfate, nitrate, sodium, potassium, calcium and magnesium. Taste, hardness and tendency for accumulation of deposits are the characteristics of drinking water associated with high TDS.

Throughout this report, the secondary standard for TDS of 500 mg/l was referenced. At this level of TDS, water is generally acceptable from the standpoint of taste and other effects not related to health. Groundwaters with less than 500 to 1,000 mg/l were considered suitable for drinking water. The higher levels of TDS do not constitute a health problem in drinking water but are considered an upper limit of acceptability for the purposes of this investigation. The World Health Organization summarizes the health effects of TDS as follows:

"There is no evidence of deleterious physiological reactions occurring in persons consuming drinking water supplies that have TDS levels in excess of 1,000 mg/l ... The results of certain epidemioligical studies would appear to suggest that TDS in drinking water may even have beneficial health effects ... Bruvold et al. ... have rated the palatability of drinking water according to the TDS level thus:

Excellent:	*Less than 300 mg/litre*
Good:	*Between 300 and 600 mg/litre*
Fair:	*Between 600 and 900 mg/litre*
Poor:	*Between 900 and 1,200 mg/litre*
Unacceptable:	*Greater than 1,200 mg/litre ...*

Although no deleterious physiological effect has been recorded with TDS in water above 1,000 mg/l, it was considered that it would, as a rule, be unacceptable to exceed this level, which is recommended as a guideline value.[4]

The average level of total dissolved solids in the Missouri River near Culbertson is 425 mg/l Communities in the region that rely on groundwater have total dissolve solids levels ranging from 748 (Brockton) to 2,730 mg/l (Fort Kipp).

6.2.3 Iron

Iron is a secondary drinking water contaminant that affects the acceptability of drinking water supplies, but does not generally have adverse health effects. High concentrations of iron cause discoloration of clothes and fixtures. Iron, in combination with high concentrations of manganese, is common in groundwater throughout the project area.

Iron is a problem in the public water systems of Bainville, Nashua, Brockton, Frazer, Medicine Lake, Plentywood, Poplar, Wolf Point, Westby, Fort Kipp and Antelope, among others. Concentrations exceed the secondary drinking water standard by several times. The recommended limit for iron (.3 mg/l) was based on taste and appearance rather than detrimental physiological effect.[5]

The National Academy of Sciences concludes that iron deficiency is common in the United States and, if local water supplies contain 0.5 milligrams per liter (0.5 mg/l), it could contribute to total iron intake. It was further concluded that iron content of drinking water should not be reduced from the standpoint of health because there is *little or no likelihood of toxicity* from iron in foods and water.

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[4] World Health Organization 1984, p. 304 et seq.

[5] NAS 1980, V-3, p. 312.

Most tap water supplies provide less than 5% of the dietary requirement for iron.[6] The three principle methods of control of iron in water supply systems are oxidation, iron exchange and stabilization. Stabilization uses dispersing agents to prevent deposition in the distribution system. Surveys in Nebraska suggest that water treatment plants are frequently unsuccessful in controlling both iron and manganese even when the concentration of those elements are low.

Flocculation in water flow in the distribution system dislodges and carries accumulated deposits. Polyphosphates are the most effective of the stabilizing agents in controlling iron according to some researchers. Dispersion of iron may not be permanent after the polyphosphate breaks down to orthophosphate. Polyphosphate should be added before oxidation or chlorination.[7] The potential adverse health effects of polyphosphates are relatively unknown.[8]

6.2.4 Manganese

Manganese is another secondary contaminant with general chemical behavior and occurrence in natural water similar to iron. Manganese is less abundant than iron in natural rocks, and as expected, concentrations in water are generally lower than iron.

Acute manganese poisoning is rare. Chronic exposure may result in crippling, but is seldom fatal. Sleepiness, twitching, leg cramps, tendon reflexes and emotional disturbances are symptoms of manganese poisoning. Manganese poisoning generally results from inhalation rather than ingestion.[9] Approximately 2 milligrams (1 mg/l equivalent) is the normal dietary intake of manganese. Isolated water samples contain manganese levels as high as 1.32 mg/l which contributes about as much as food to the total manganese intake.[10]

Manganese creates discoloration and undesirable taste in drinking water. These problems arise at concentrations of manganese greater than .05 mg/l.

As discussed above, manganese and iron are common in the project area and require removal in many communities, generally through sand filters. The manganese standard is .05 mg/l, and observations of manganese in the project area range from .12 mg/l in St. Marie to 2.37 mg/l in Medicine Lake.

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[6] NAS 1980, V-3, pp. 311-312.

[7] NAS 1982, p. 94.

[8] NAS 1992, p. 95.

[9] NAS 1982, p. 3.

[10] NAS 1980, p. 337.

6.3 Primary Inorganic Contaminants

6.3.1 Arsenic

Arsenic in the regional public water systems ranges from non-detectable levels to 23 µg/l in Plentywood. The Missouri River at Culbertson carries dissolved arsenic with a maximum observed concentration of 4 µg/l and total arsenic (combined with suspended settlements) with a maximum observed concentration of 70 µg/l. Average dissolved and total arsenic levels in the Missouri River at Culbertson are 2.8 and 9.97 µg/l, respectively, based on miscellaneous measurements by the U. S. Geological Survey from 1974 through 1994.[11]

Maximum contaminant level (MCL) for arsenic was reviewed by EPA and lowered from 50 to 10 micrograms per liter (µg/l) on October 31, 2001.[12] Water systems must comply by January 2006. The revision for arsenic followed a request for comment by EPA on 3 µg/l (feasibility level), 5 µg/l (proposed June 2000), 10 µg/l (January 2001 rule) and 20 µg/l.[13] The National Research Institute recently concluded that:

> *...The results of this subcommittee's assessment are consistent with the results presented in the NRC's 1999 Arsenic in Drinking Water Report and suggest that the risks for bladder and lung cancer incidence are greater than the risk on which the EPA based its January 2001 pending rule...*[14]

The lowered standard for arsenic will require further examination of concentrations in the Missouri River at the intake site. While existing data suggests that the raw water of the Missouri River available to the project does not have concentrations exceeding the new standard, arsenic serves to illustrate the need for adaptability in the water treatment plant. Without provision for supplemental processes, a water treatment plant would remove contaminants carried in suspension but would not necessarily remove dissolved arsenic or other contaminants that may be the subject of future safe drinking water regulations. The treatment plant must provide a product to a future nano filter, reverse osmosis or more appropriate process to remove contaminants that are presently not known to have an impact on human health at levels currently regulated.

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[11]There were 50 measurements of dissolved arsenic and 35 measurements of total arsenic at gaging station 06-1855 operated as part of the Stream Water Quality Network (NASQAN) and found at the following site: http://water.usgs.gov/nasqan/data.

[12]Letter of October 31, 2001, from Administrator, Christine Todd Whitman, to The Honorable C. W. Young, Chairman, Committee on Appropriations, House on Representatives.

[13]Federal Register, Vol. 66, No. 194, Oct. 5, 2001, p. 50761.

[14]Subcommittee to Update the 1999 Arsenic in Drinking Water Report, September 2000, Prepublication Copy, *Arsenic and Drinking Water: 2001 Update*, Committee on Toxicology, National Research Institute, p. 12.

Arsenic is a naturally occurring element associated with geothermal and volcanic activity. In Montana the source of arsenic in both the Upper Missouri and Yellowstone Rivers is Yellowstone Park. The new rules and regulations will require Montana communities along those rivers to modify their treatment processes to remove arsenic. Billings has undertaken to remove arsenic in advance of the new regulations.

The Yellowstone River at Billings carries average dissolved and total arsenic levels of 9.6 and 17.3 μg/l, respectively. Maximum observed concentrations for dissolved and total arsenic are 20 and 70 μg/l, respectively.[15] In both cases, the Yellowstone River is carrying higher levels of arsenic than the Missouri River near Culbertson, the latter of which is a sound indicator of arsenic levels along the Missouri River between the confluence of the Milk and Yellowstone Rivers.

Because the average arsenic concentrations in the Missouri River near Culbertson are low (2.8 μg/l) relative to the proposed standard, the treatment strategy would be similar to that of Billings, namely removal of non-dissolved arsenic as part of the ongoing removal of suspended sediments or turbidity. Billings has modified its flocculation process to remove turbidity, finding that the removal of arsenic as part of the removal of turbidity is more effective with ferric chloride as the flocculating agent than the conventional alum floc.[16] Billings achieves arsenic removal to the extent that remaining residual concentrations are under 2 to 3 μg/l. In addition to coagulation/filtration, EPA identifies ion exchange, activated alumina, reverse osmosis, lime softening and pre-oxidation as best available technologies with the potential for removing 80% to 95% total arsenic. Waste (sludge) disposal is also a matter requiring attention.

Earlier concerns with arsenic that influenced the adoption of a standard at 50 μg/l were related to a risk assessment for skin cancer based on Taiwanese studies involving a low-income population with poor diets and low quality of medical care exposed to high concentrations of arsenic. More recently, studies have been conducted on the same Taiwanese population in combination with evidence from Chile and Argentina related to the risk of bladder and lung cancers. On the basis of a cost and benefit analysis, as reproduced in Table 6-2, EPA concluded that the feasible level for arsenic regulation was 3 μg/l, but EPA proposed an arsenic MCL of 5 μg/l.

At the 3 μg/l level (Table 6-2), total national costs to community water systems to remove arsenic were estimated by EPA to range between $643 and $753 million. Bladder cancer benefits (reduced incidence and associated costs) were estimated to range between $43.6 and $104.2 million, and lung cancer benefits were estimated to range between $47.2 and $448 million.[17] If the upper level

[15] See Note 11, *supra*, for station 06-2145.

[16] Personal Communication, City of Billings, December 22, 2000.

[17] Federal Register, October 20, 2000, *National Primary Drinking Water Regulations; Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring*, Vol. 65, No. 204, p. 63031, *et seq.*

of costs were used ($753 million) and the upper level of benefits in reduction of the cost of cancer incidence were used ($552.2 million), the benefit to cost ratio of removing arsenic would be calculated at .73 or the equivalent of $0.73 in benefits for each $1.00 in cost to remove arsenic. As shown in Table 6-2, the benefit to cost ratio increases for decreasing levels of arsenic removal. The EPA conclusion of feasibility at the 3 μg/l level was based on a calculation of benefit to cost ratio using the upper limit of benefits and the lower limit of costs.

Table 6-2 also presents the risk of lifetime incidence of bladder and lung cancer per 100,000 members of the population for each of the arsenic MCL levels under consideration. There are numerous analyses presented by EPA of risk factors based on a variety of assumptions and methods, and only a single set of conclusions is presented in Table 6-2. The conclusions are illustrative of the benefits of lowering the arsenic MCL with a combined risk of bladder and lung cancer at the 20 μg/l level of 84 lifetime incidences per 100,000 persons and a risk at the 3 μg/l level of 24 incidences per 100,000 persons.[18] Note that the estimates of lung cancer incidence are

TABLE 6-2

ESTIMATED COSTS AND BENEFITS FROM REDUCING ARSENIC IN DRINKING WATER
(1999$ in Millions)

Arsenic Level (μg/l)	Total National Costs to CWSs	Total Bladder Cancer Benefits	"What If" Lung Cancer Benefits	Cost Upper Limit	Benefit Upper Limit	Benefit to Cost Ratio
3	$643.1-753	43.6-104.2	47.2-448	753.0	552.2	.73
5	377.3-441.8	31.7-89.9	35-384	441.8	473.9	1.07
10	163.3-191.8	17.9-52.1	19.6-224	191.8	276.1	1.07
20	61.6-72.9	7.9-29.8	8.8-128	72.9	102.7	1.44

TABLE 6-3

LIFETIME INCIDENCE RISKS PER 100,000 POPULATION, 90TH PERCENTILE

Arsenic Level (μg/l)	Morales Risk Bladder Cancer	Morales Risk Lung Cancer	Upper Limit Combined Risk
3	10-12	10-12	24
5	18-20	17-21	41
10	26-31	27-31	62
20	35-41	34-43	84

[18] *Ibid*, p 63032

comparable to those of bladder cancer, leading EPA to conclude that *"... based upon this most recent risk information, ... the combined risk of excess cases of lung and bladder cancer attributable to arsenic in drinking water could be at least twice that of bladder cancer alone..."*[19]

A review of the arsenic concentrations in the existing public water systems as presented in Table 6-2 discloses that some existing water systems will require repeat measurements of arsenic levels to determine the validity of historic observations for current water sources. If the reported levels are confirmed, investment in facilities and annual operations to remove arsenic may be required in the future. The regional water project will remove arsenic from Missouri River water and will maintain arsenic levels below the 3 μg/l level at or near the cost levels presented in this document.

6.3.3 Radionuclides

Radionuclides were examined as shown in Table 6-2. Regulations in the future will provide for MCL's for the constituents of gross alpha: radium 226, radium 228, radon and uranium. Currently there is no evidence that radionuclides are contaminants of concern in either the existing groundwater sources or in the Missouri River.

6.3.4 Sulfates

Table 6-2 identifies several communities in the project area that exceed the proposed sulfate MCL of 500 mg/l. The proposed sulfate rule was announced by EPA on December 20, 1994.[20] EPA noted a potential adverse health effect for infants, travelers and new residents to areas with high sulfate levels in drinking water. The objective of the rule was to ensure that sulfate levels in drinking water provided by public water systems are reduced below levels of concern. The health effect associated with ingestion of high levels of sulfate is diarrhea. EPA considered these effects to be acute but temporary (expected to last approximately two weeks). The health risk applies to persons not acclimated to high sulfate water.

The proposal allowed for four options for compliance. Option 1 would require provision of an alternative to the public water system for both transient adults (travelers and new residents) and infants. Options 2 and 3 would require public notification/education but would only require the provision of bottled water (which complies with EPA MCL's) to infants. In option 3 public notification/education would be considered adequate protection for adults. EPA also considered a fourth, more conventional option. This option would permit systems to seek a variance from the sulfate MCL. As a condition of receiving a variance, systems would be required to provide alternative water to their target populations, comparable to option 1. EPA expected that from 1,500 to 2,000 affected systems would choose option 1 with an estimated annual cost of $7 million. EPA assumed that another 500 systems would choose central treatment or regionalization in spite of the availability of the new regulatory approach of option 1. The cost to those systems was estimated at $71 million. If central treatment were the only

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[19] *Ibid.*

[20] Federal Register, Dec. 20, 1994, *Drinking Water; National Primary Drinking Water Regulations -- Sulfate Proposed Rule*, EPA; National Primary Drinking Water Regulation Implementation, Volume 59.

means of compliance with the sulfate rule, EPA estimated the annual national cost at $147 million (household costs ranging from $244 to $811 per year, $20 to $70 per month). The two best available technologies identified by EPA for sulfate removal were reverse osmosis and ion exchange. EPA has included sulfate among other contaminants to be considered for regulation by August 2001.

As part of the issuance of a final rule, EPA conducted an investigation of the health effects from exposure to sulfate in drinking water.[21] EPA stated that the purpose of its investigation was to examine the association between consumption of tap water containing high levels of sulfate and reports of diarrhea among infants and transients. EPA was unable to conduct a study of infants because they were unable to identify enough exposed individuals from which to draw a study population. More than half of the pregnant women who completed the EPA survey intended to breast-feed their infants, and most of those who planned to use formula did not intend to use tap water to mix formula. In experimental trials with adult volunteers, a statistical association between acute exposure to sulfate in tap water (up to 1,200 mg/l) and diarrhea was not evident.

The regional project will eliminate sulfate as a contaminant in drinking water thereby eliminating health effects for infants and transients. Existing systems could not remove sulfate from their drinking water supplies without significant investment but could continue to operate under the EPA proposed rule without removing sulfate through the options discussed above, none of which would require investment in new treatment facilities.

6.3.5 Fluoride

Fluoride is discussed as an additive to drinking water supplies to enhance dental health. It does not occur naturally in the existing public water systems of the project area at levels to be of concern as a contaminant. The public is often interested in the health effects of fluoride.

The National Academy of Sciences makes the following statement with regard to fluoride.

> *... There is no generally accepted evidence that anyone has been harmed by drinking water with fluoride concentrations considered optimal for the annual mean temperatures in the temperate zones. It seems likely, however, that objectionable dental fluorosis occurred in two children with diabetes insipidus. Bone changes, possibly desirable, have been noted in patients being dialyzed against large volumes of fluoridated water. Similar changes can be expected in the rare renal patient with a long history of renal insufficiency and a high fluid intake that includes large amounts of tea. With this particular combination of circumstances, the lowest drinking water concentration of fluoride associated*

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[21] EPA, January 1999, *Health Effects From Exposure to High Levels of Sulfate in Drinking Water Study,* Office of Water, EPA 815-R-99-01.

with symptomatic skeletal fluoride that has been reported to date is 3 mpl [milligrams per liter] ... *occasional objectionable mottling would be expected to occur in communities in the hot regions of the United States with water that contains fluoride at 1 mpl or higher and in any community with water that contains fluoride at 2 mpl or higher. ... The possibility of fluoride causing other adverse effects (allergic responses, mongolism, and cancer) or for beneficial effects other than decreased dental caries has not been adequately documented to carry weight in the practical decision about the desirable levels of fluoride. ... From a scientific point of view, none of these effects can be ruled out but the available data are rather limited or not easily improved so further study is indicated.*[22]

According to the National Academy of Sciences, dietary amounts of fluoride range from 1.73 to 3.44 µg/day with intake from water ranging from 0.53 to 1.27 µg/day.[23] The National Research Council estimated *adequate and safe* intakes ranging from 0.1 to 0.5 µg/day for infants less than 6 months of age to 1.5 to 4.0 µg/day for adults. There is no *recommended* daily intake of fluoride. The levels considered *adequate and safe* provide protection against dental decay and osteoporosis.[24]

Dental decay has been associated with low fluoride diets, and protection against decay has been observed in subjects with drinking water containing up to 1.3 µg/l of fluoride. Because more drinking water is consumed in hotter climates of the United States, lower concentrations of fluoride are considered adequate to prevent dental decay in those areas. Fluoride benefits in the prevention of dental decay are greatest in children less than 8 years old. The amount of fluoride consumed during this period provides the principle protection against tooth decay, rather than the fluoride concentration in the drinking water after the calcification of the teeth.[25]

Surveys of other parts of the population of the United States by the Public Health Service prior to 1970 showed that 8.1 million people were consuming water with natural fluoride levels exceeding 0.7 µg/l. One million people have natural fluoride concentrations of more than 2 µg/l.[26]

Food that is high in fluoride includes fish, such as sardines, and tea. Fruits and milk are generally low in fluoride, and vegetable fluoride concentrations vary.[27]

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[22] NAS 1977, pp. 398 and 399.

[23] NAS 1980, p. 279.

[24] NAS 1980, p. 280.

[25] NAS 1980, p. 281.

[26] NAS 1977, p. 70.

[27] NAS 1977, p. 371.

Fluoride can cause death at levels of about 5 grams. Abdominal pain, nausea and diarrhea are typical symptoms.[28] Teeth and bone are most sensitive to long-term exposure to fluoride. Dental mottling (discoloration of the teeth involving brown spots) is a long-term effect. One μg/day, (equivalent to approximately 0.5 μg/l in drinking water) is 2 to 8 times less than the fluoride intake that will produce mottling. This concentration is also as much as 20 to 40 times less than the daily intake that will result in crippling effects on the bones of the skeleton. From 1 to 5 μg/l fluoride in drinking water may prevent bone loss in older people, a condition that leads to osteoporosis.[29] Mongolism, a congenital disease characterized by mental deficiency, has been associated with fluoride, but the research has been discounted. Claims have been made that certain people are more sensitive to fluoride than others, but that research is discounted on the basis of data indicating that tea drinkers do not appear to be more sensitive to high levels of tea ingested.[30]

Research has shown differences in cancer rates between larger U. S. cities that have fluoridated and non-fluoridated drinking waters. That research has been significantly criticized. When examination was made of the link between fluoride and cancer types, stomach cancer was possibly linked to fluoride, but evidence of the linkage was not considered strong. The National Academy of Sciences concluded as follows:

> *... Other observations of possible positive correlations between fluoride intake and cancer, although inconclusive, deserve attention and further investigation.*[31]

6.4 Microbiology and Turbidity

6.4.1 Filtration

Removal of microbiological contaminants and turbidity was the first important step in the treatment of surface waters in the 1800s. A cholera epidemic in 1892 in Germany was studied in the communities of Hamburg and Altona. Both withdrew water from the Elbe River. Altona was downstream and filtered its water to remove raw sewage discharged into the river by Hamburg. It was observed that filtration at Altona resulted in a lower incidence of cholera even though that city had seemingly inferior water supply when compared with Hamburg.[32]

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[28] NAS 1977, p. 376.

[29] NAS 1977, p. 377.

[30] NAS 1977, p. 378.

[31] NAS 1977, p. 387.

[32] NAS 1977, pp. 2 and 3.

Similar examinations of the Merimac River at the city of Lawrence, Massachusetts, after 1887 demonstrated that a marked reduction in typhoid fever incidence followed the construction of a sand filter along the river. The death rate from typhoid fever dropped by 79% in the five years following the construction of the sand filter when compared with the death rate during the five years prior to the filter construction.[33]

Current and proposed EPA standards for microbiology and turbidity, as discussed in this section, had their origins in the history of the Elbe and Merimac rivers.

In this project, groundwater received from properly constructed and protected wells is naturally filtered, and water borne diseases should not be present. However, improper construction of public water system and private wells can result in biological contamination in the vicinity of the well. If surface water can enter the well from the top of the casing or around the casing, there is potential for biological contamination. If water draining from the septic tank can be intercepted by the cone of depression surrounding the well, then contaminated, septic water can reach the well. If livestock are using the area in the vicinity of the well, animal wastes can be carried into the groundwater where the biological contaminants can be drawn into the well. Care is needed in the location of public water system and private wells considering these factors. Moreover, wells should be drilled to sufficient depth to ensure that groundwater contamination near the water table is not conducted into the well.

All water drawn from the Missouri River by existing public water systems is filtered, and all water drawn from the Missouri River by the regional project will be similarly filtered. The regional project will provide continuous monitoring of turbidity at each filter to demonstrate that 95% of the monthly effluent is maintained at less than 0.3 NTU (turbidity units) to meet the MCL "treatment technique" requirements. In actual practice turbidity will be monitored at less than 0.1 NTU, which is reflected in the current operations of Culbertson, for example.

6.4.2 Chlorination

The public and school water systems throughout the region provide chlorination as a precautionary measure to ensure that groundwater carrying water-borne disease does not infect the drinking water supplies. Chlorination is regarded as the singlemost significant advance in water treatment. It was introduced after 1908 to provide a method of ensuring the bacteriological quality of water. Chlorination was first haled as a breakthrough technology in Jersey City, New Jersey. The city had complained that the private water company delivering water from the Rockaway River had not provided filtration. The water was not pure and wholesome for drinking at all times as required by the contract with the private company. The private company serving Jersey City chose to try chlorination as an alternative to filtration and as a means of controlling disease from sewage discharges by

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[33] *Ibid.*

communities upstream from Jersey City on the Rockaway River. In the litigation that followed, the Court found as follows:

> *I now therefore find and report that this device [chlorination] is capable of rendering the water delivered to Jersey City pure and wholesome for the purpose for which it is intended and is effective in removing from the water those dangerous germs which are deemed by the decree to possibly exist at certain times.*[34]

Giardia, *Cryptosporidium*, *Legionella*, heterotrophic bacteria, total coliform, fecal coliform, and viruses are currently regulated with an MCLG of 0 using treatment techniques to meet requirements.

The current MCL for total coliform is no more than 1 positive sample from an estimated 40 samples or no more than 5% for over 40 samples per month. Every sample testing positive for total coliform will be analyzed for fecal coliform.

Current EPA regulations for *Giardia* and viruses provide the following:

> *Disinfection* with filtration *must achieve at least 99.9 and 99.99 percent removal/inactivation of Giardia cysts and viruses, respectively. The State [*Tribes*] define the level of disinfection required, depending on technology and source water quality. Disinfection requirements for point of entry to the distribution system and within the distribution system are the same as for unfiltered systems.*[35]

Private wells are more subject to biological contamination than the public and school water systems. Periodic sampling of individual wells is useful to demonstrate that local runoff, septic systems or other factors are or are not producing biological activity that poses unreasonable risks to health.

6.4.3 Disinfection Byproducts

Existing water systems currently monitor chlorine, chloramines and/or chlorine dioxide to maintain chlorine residuals above 0.2 mg/l entering the distribution system, and no significant changes will be implemented with the regional system, although chloramines are contemplated as the disinfection agent in order to better comply with the disinfection byproduct rules.

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[34] NAS 1977, p. 5.

[35] EPA May 1990, p. 19.

Because public water systems are disinfected by chlorine, monitoring of trihalomethanes (TTHMs) and haloacetic acids (HAA5) is required. The standards for TTHM and HAA5 are .08 mg/l and .060, respectively[36], but standards proposed by May 2002 are 0.04 and .05 mg/l, respectively.[37]

6.4.4 Groundwater Rule

EPA proposed a groundwater rule as a risk-based regulatory strategy for all groundwater systems on May 10, 2000.[38] The ruled is proposed to be final by late 2000. The proposed strategy addresses the public health risk associated with consumption of waterborne pathogens from fecal contamination through a multiple-barrier approach that relies on the following five major components:

- periodic sanitary surveys of groundwater systems;
- hydrogeologic assessments to identify wells sensitive to fecal contamination;
- source water monitoring for systems drawing from sensitive wells without treatment;
- a requirement for correction of significant deficiencies and fecal contamination; and
- compliance monitoring to insure disinfection treatment is reliably operated where used.

As discussed previously, most existing public water systems rely on groundwater for source and provide chlorination for disinfection. The future groundwater rule should not have an adverse impact on costs within existing systems. Therefore, the estimates by EPA of average annual household costs for disinfection, ranging inversely from $1.95 to $16.00 per month per household for systems serving 3,300 to as few as 100 persons, respectively, should not adversely impact current levels of water billing.[39]

6.5 Water Treatment Processes

6.5.1 Raw Water Characteristics

The proposed intake will screen and divert water directly from the Missouri River with screen size and intake velocities designed to minimize impact, if any, on fishery resources. It will contain arsenic in concentrations discussed in Section 6.3.1.

The raw water is also expected to contain total organic carbon in concentrations averaging 2.76 mg/l based on data collected and analyzed by the U.S. Geological Survey at its National Stream Water

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[36] EPA May 1990, p. 38.

[37] EPA May 1990, p. 40.

[38] Federal Register, May 10, 2000, *National Primary Drinking Water Regulations: Ground Water Rules; Proposed Rules*, Vol. 65, No. 91, p. 30194, *et seq*, Environmental Protection Agency.

[39] *Ibid*, p. 30248

Quality Network (NASQAN) station on the Missouri River at Culbertson (06185500). Total organic carbon ranges from values near 0 mg/l to 16 mg/l based on 31 measurements in all seasons of the year and covering the period from 1996 through 1999[40]. Most total organic carbon (from the available record) occurs in the fall and winter months when regional water demands are at their lowest. Lower concentrations are observed in the May through September time frame based on available measurements. This may be due to releases from Fort Peck Dam during the fall and winter that carry algae and other aquatic plant life grown during the summer months that decomposed at the end of the growing season.

Organic carbon is available in dissolved and suspended form, but unlike arsenic, removal of suspended solids does not necessarily remove organic carbon. While highest levels of total organic carbon (TOC) range as high as 16 mg/l, suspended organic carbon accounts for as much as 14 mg/l (from the available record).

TOC is proposed for regulation by EPA for disinfection byproducts. Source water, using conventional treatment and containing alkalinity greater than 120 mg/l, will be required to use enhanced coagulation and/or enhanced softening to remove 15% TOC for concentrations in the 2.0 to 4.0 mg/l range and 30% TOC for concentrations greater than 8 mg/l.[41]

Alkalinity measured by the U.S. Geological Survey at the Culbertson gaging station ranges from 90 to 210 mg/l and averages 150 mg/l. When alkalinity is in the lower range of experience, TOC removal of 25% and 40% , respectively, is proposed by EPA. Large surface water systems (greater than 10,000 persons) would be required to sample at the plant on a monthly basis for TOC and alkalinity. Conventional filtration treatment systems must monitor (1) source water TOC prior to any treatment and (2) treated TOC at the same time in paired samples.[42] Removal of TOC at the levels proposed by EPA may not be feasible for many public water systems. In the event a public water system cannot provide the necessary percentage TOC removal, jar test procedures are proposed by EPA for determining the point at which addition of alum or an equivalent dose of a ferric coagulant has reached a point of diminishing returns and further removal is infeasible.[43] Jar testing for TOC removal is proposed for this project in final design.

EPA initially disallowed pre-disinfection credit in order to maximize removal of organic precursors prior to the addition of disinfectant However, based on comments from public water systems, the proposed rule does not impose constraints on the practice of pre-disinfection as proposed at the Poplar water treatment plant. Credits will be applicable for pre-disinfection.

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[40] water.usgs.gov/nasqan/data/finaldata/culbertson.html

[41] Federal Register, Vol. 63, No. 241, Dec. 16, 1998, *Summary of Final Stage 1 Disinfection Byproduct Rule*, p. 69396.

[42] *Ibid*., p. 69422

[43] *Ibid*., p. 69413.

TABLE 6-4

SUSPENDED SEDIMENT AND TURBIDITY
% OF TIME VALUES ARE LESS THAN INDICATED

% Less Than	Suspended Sediment (mg/l)	Turbidity (NTU)
10	60	6
20	110	10
30	170	15
40	230	22
50	300	35
60	380	55
70	480	85
80	600	130
90	770	200
95	940	255
100	2,000	300

Suspended sediments, an indicator of turbidity, will also be carried by raw water diverted from the Missouri River. Removal of suspended sediments (turbidity) will remove most arsenic, as discussed above, and some TOC. Suspended sediments at the U.S. Geological Survey gaging station at Culbertson averaged 410 mg/l and ranged from 35 mg/l (11,700 cfs) to 1,930 mg/l (26,600 cfs) for a limited number (30) of samples collected in the late 1990s. Analysis on the data suggest the following frequency of suspended sediments: less than 60 mg/l 10% of the time, less than 300 in mg/l 50% of the time, less than 600 mg/l 80% of the time and less than 940 mg/l 95% of the time. Table 6-4 summarizes estimated frequencies of both suspended sediments and turbidity.

The Corps of Engineers proposes to release water from Fort Peck Dam in a "spring rise", to benefit endangered species along the 141 mile boundary of the Fort Peck Indian Reservation, part of the 200 mile segment to be affected:

> *In the 200-mile reach of the Missouri River below Fort Peck, the FWS has recommended increased spring flows and increased water temperatures during the open water period, on average, once every 3 years. The FWS believes such action would increase the overall quality and quantity of riverine habitat, provide spawning cues, and improve recruitment success for pallid sturgeon and other native river fish species.*[44]

Estimates have been made that the spring rise will increase long-term suspended sediment discharge by 7%, primarily during a two to three-week period in which the "spring rise" is implemented. This

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[44]U. S. Army Corps of Engineers, December 2000, *Draft Implementation Plan For the Final Biological Opinion on Operation of the Missouri River Main Stem Reservoir System, Operation & Maintenance of the Missouri River Bank Stabilization & Navigation Project, & Operation of the Kansas River Reservoir System*, Northwest Division, p. 5.

increase can be managed by the water treatment plant, but will increase costs of operation during the "spring rise." In addition to the increasing suspended sediments, the "spring rise" is expected to increase temperature and bank erosion. The intake must be designed to accommodate forces tending to erode the intake site. Temperature changes may require alteration of water treatment processes to inhibit the formation of disinfectant byproducts.

6.5.2 Processes

Missouri River raw water, as described in the previous section, can be treated satisfactorily by several treatment methods (micro-filtration with Superpulsator™ clarifier or equivalent, media-filtration with Superpulsator™ clarifier or equivalent and conventional treatment) to meet federal safe drinking water criteria. These alternatives will be investigated in more detailed design-level studies outside the scope of this document, and a selection will be made based on costs and the ability to produce a high quality dependable finished water supply . For more detail respecting these alternatives, Appendices A and B may be consulted.

Water treatment at the regional plant will involve the removal, including filtration, of suspended particles from the raw water and disinfection of the filtered water to remove microorganisms. The following processes are potentially available within the proposed treatment plant, subject to requirements to produce a finished product meeting federal safe drinking water standards and public opinion respecting matters such as fluoridation and methods of disinfection:

- potassium permanganate oxidation;
- powdered activated carbon absorption;
- alum (or ferric chloride) and cation coagulation;
- flocculation;
- sedimentation;
- gravity filtration;
- pH modification;
- corrosion inhibitors;
- disinfection (chlorimination with consideration of ozone for partial disinfection);
- fluoridation.

While direct filtration treatment plants are operating along the Missouri River in downstream states, without treatment processes involving sediment removal before filtration, this alternative was eliminated from consideration on the basis that suspended sediments in relatively high concentrations enter the Missouri River below Fort Peck Dam from the Milk River, among other tributaries, during runoff periods. Moreover, the distance between the intake location and Fort Peck Dam is sufficient to produce suspended sediments from bank erosion along the River and from other sources. On the other hand, some treatment processes can be bypassed to lower operating costs during some periods of the year when raw water quality does not require all the processes associated with sediment removal before filtration and direct treatment can be effective.

The regional water treatment plant can provide a product to a future nano-filtration, reverse osmosis or other comparable process to remove contaminants that are not known to have an impact on human health at levels currently regulated.

Table 6-3 summarizes the general process of treating water delivered from the raw water intake on the Missouri River to the finished water in the clear well before entry to the distribution system.

Pre-Oxidation

Potassium permanganate would be added (as necessary) as the initial chemical to promote oxidation and minimize taste and odors. This would be accomplished with the delivery of raw water to a pre-oxidation basin followed by an in-line (or other similar type of) rapid mixer with controls to prohibit backflow of chemicals. Depending on final site conditions, the raw water pipeline from the intake may be used as the “pre-oxidation basin” if an adequate contact time (15 to 30 minutes) can be achieved prior to the water treatment plant rapid mixer.

Mixing, Coagulation and Flocculation

Mixing, as referred to above, is a process to uniformly disperse chemicals added for coagulation through the raw water taken at the intake. Coagulation is the addition of chemicals that destabilizes the forces among particles that keep them apart and promotes their attachment to one another for removal as the treatment process progresses. These particles may be silts, clays and organic matter that remains suspended in the source water. Enhanced coagulation will be designed to remove organic material to comply with the disinfectant byproducts rules. This will be accomplished by increasing chemical dosage and/or pH adjustment. Ferric chloride is the preferred coagulant by other surface water treatment plants in the region as a means of achieving arsenic removal. The most common coagulant, absent the presence of arsenic, is alum (aluminum sulfate).

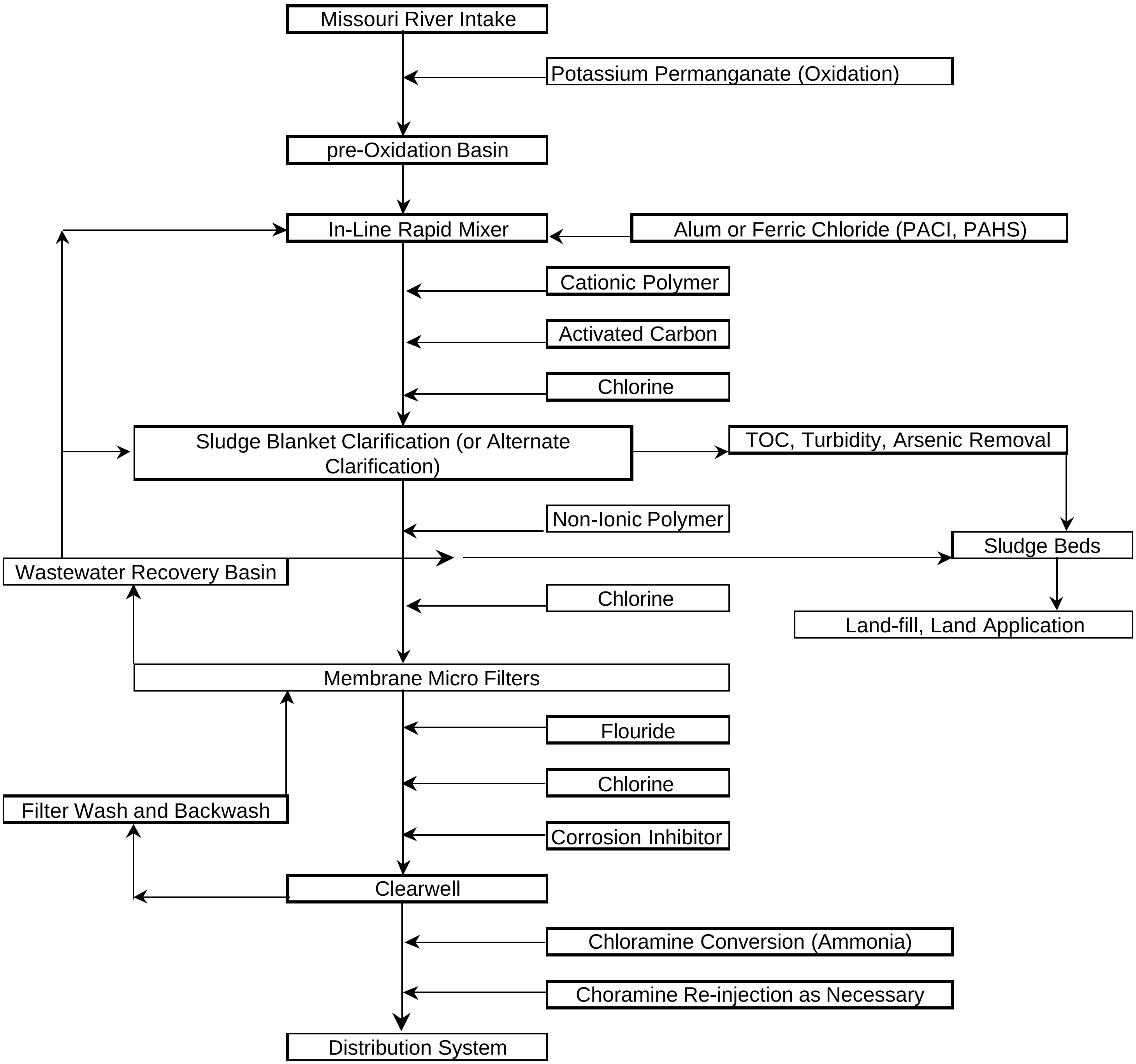
Flocculation is the process that settles suspended particles and follows the addition of coagulation chemicals. In a conventional water treatment plant, flocculation occurs in sedimentation basins prior to the clarification process. Agents that can aid the flocculation process include cationic or anionic polymers, activated silica and bentonite.

The rapid mixing, coagulation and flocculation processes may be combined in proprietary devices, such as a Superpulsator™. Pilot studies will be undertaken to determine the whether separate facilities for rapid mixing, coagulation and flocculation consistent with a conventional water treatment plant will be utilized or whether these processes will be combined in a proprietary clarifier.

Alum or ferric chloride would be added to the rapid mixer for coagulation. Ferric chloride will be used if needed to enhance arsenic removal. Alum will be used if arsenic can be successfully removed with turbidity. Polyaluminum chloride (PACL) and partially neutralized alum-polyaluminum hydroxy sulfate (PAHS) are alternative coagulants. Selection of a final coagulant will be based on effectiveness of turbidity reduction, arsenic removal, organics removal, impact on disinfection byproduct reduction, sludge production, pH and corrosion impacts, ease of handling and storage, and costs.

TABLE 6-5

WATER TREATMENT PROCESSES



Clarification

Clarification will reduce the remaining suspended sediments, including organics, after the coagulation and flocculation processes, or combined with these processes, before filtration to. Alternatives for clarification and include membrane filtration and media filtration. Membrane filtration may include microfilters or nano filters. The latter will remove particles sizes that are 1,000 times smaller than the particle sizes removed by microfilters. This level of removal is not considered necessary for this project.

Before entering the clarifier, cationic and non-ionic polymers, activated carbon and the first stage of chlorine injection for disinfection will be provided as necessary. The principal difference in the water treatment process discussed here and a conventional treatment process is the substitution of sludge blanket clarification (or another alternative clarification system) for conventional flocculation/sedimentation. The clarifier will remove suspended organic carbon (a precursor to formation of disinfectant byproducts), turbidity and suspended arsenic. These contaminants will be delivered to sludge beds and thereafter to landfill or land application, depending on compliance requirements for the final concentrations of constituents that are produced.

Preliminary costs estimates indicate that a pulsed blanket clarifier may be more cost- effective than conventional flocculation/sedimentation. Detailed sizing based on recommendations from manufacturers and a review of other facilities treating similar waters should be performed before this clarifier system is selected. Pilot testing may be warranted since this process does not work well with all types of waters and contaminants. In addition to the pulsed blanket clarifier, other types of alternative flocculation/sedimentation systems should be evaluated, including:

- Solids contact clarification.
- Conventional (not pulsed) sludge blanket clarification.
- Contact clarification.
- Ballasted clarification.

It is not contemplated at present that arsenic in the waste sludge will be of sufficient concentration to cause concern with any disposal method. Emphasized is the fact that arsenic removal is part of the planning process, but removal of turbidity is expected to remove arsenic to the point that the remaining dissolved concentration will be well below a 10 μg/l level.

Filtration

From the clarifier water will be delivered to gravity micro (membrane) or media filters. Conceptual value engineering of the water treatment plant determined that conventional gravity media filters would be less costly than membrane filters, but both alternatives will be re-examined in final design of the water treatment plant. Before water is delivered to the filters, additional injection of chlorine for disinfection, polymers and corrosion inhibitors is proposed. Beyond the filters, fluoride is proposed for injection, depending on public acceptance, as a beneficial dental treatment. Additional chlorine and conversion to chloramines through addition of ammonia is proposed to finish the treatment of water before and after the clearwell. Part of the finished water delivered to the clear well will be used to wash the surface and backwash the filters. The wash water will then be delivered to a recovery basin and thereafter to sludge drying beds or returned to the front of the treatment process at the in-line rapid mixer or to the clarifier, depending on quality of the wash water. This latter phase in the process will be an operational decision based on conditions that will vary throughout the seasons and the year.

6.5.3 Disinfectants and Disinfectant Byproducts

Alternatives for disinfectants include chlorine, chlorine dioxide, chloramines, ozone, ultraviolet light and combinations thereof. Because residual levels of disinfectant are required in the finished water, any use of ozone or ultraviolet light must be followed by chlorine or chloramines to complete the disinfection process and provide a residual.

Ultraviolet light was not considered here. Some consideration may be given to ozone, which is gaining in popularity in combination with chloramines (a secondary disinfectant). This combination generally produces better taste than chlorination. Ozone is particularly effective in achieving log 3 (99.9%) removal or inactivation of *Giardia Lambia* cysts and log 4 (99.99%) removal or inactivation of viruses.[45]

Chloramines are formed from the reaction of chlorine and ammonia in the following steps:

(1)	$Cl_2 + H_2O$	➔	$HOCL + H^+ + Cl^-$	
(2)	$NH_3 + HOCl$	➔	$NH_2Cl + H_2O$	monochloramine
	$NH_2Cl + HOCl$	➔	$NHCl_2 + H_2O$	dichloramine
	$NHCl_2 + HOCl$	➔	$NCl_3 + H_2O$	nitrogen trichloramine

The competing reactions in the second step are dependent on pH, the chlorine: ammonia nitrogen (Cl_2:N) ratio, temperature and contact time.[46] Monochloramine is the preferred form due to its disinfectant properties and minimal taste and odor.

Chloramine residuals may be maintained for as many as 21 days[47] or significantly longer than chlorine residuals. Thus, chloramines are of considerable interest in regional water projects of the

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[45] US Bureau of Reclamation, January 2000, *Red River Valley Water Needs Assessment, Phase II, Appraisal Of Alternatives to Meet Projected Shortages*, Dakotas Area Office, p 4-1.

[46] EPA, April 1999, *EPA Guidance Manual, Alternative Disinfectants and Oxidants*, p. 6-1, *et seq*.

[47] Bureau of Reclamation, April 30, 2001, *Value Engineering, Fort Peck Assiniboine and Sioux Water Supply System, Dry Prairie Rural Water System, Final Report*, p. 53

nature here with long distances between the points of initial disinfection and end-users. The number of re-injection points to maintain residual concentrations of disinfectant can be minimized. Chloramines form very few disinfection byproducts and are superior to chlorine in maintaining low levels of total trihalomethanes (TTHMs) and haloacetic acids (HHAs). Trihalomethane reductions of 40 to 80% are reported when chlorination was replaced with chlorimination. Haloacetic acids may not be as effectively controlled by chloramines.[48] Contact time for chloramines is significantly greater than with chlorine.

Disadvantages of chloramines include requirements to remove chloramines before use in kidney dialysis. This will require attention in the project area where diabetes is so prevalent among the numbers of the Assiniboine and Sioux Tribes. Chloramine will bind to iron in the red blood cells during the dialysis process. Treatment centers can remove chloramines ahead of the dialysis process.[49] Although not considered as aggressive as chlorine, chloramine contributes to bladder and other cancer risks.

Nitrification is a risk, particularly in warmer waters. Ammonia from chloramine is converted to nitrite and then to nitrate. This can deplete the chloramine residual and increase bacterial production. Chloramines can also lead to accelerated corrosion and degradation of

gaskets and some metals in distribution systems. Temperature, pH, ammonia concentration, organic compounds, detention time and the time that water may stand in dead-end lines or other parts on the distribution system are among the factors that require attention with use of chloramines.[50]

The parts of the distribution system that are most distant from the water treatment plant are those in the northwest corner of the project on the ends of the branches north and west of Opheim. Average velocities will decline from an estimated 3.00 to 0.75 feet per second during low demand periods of the winter, and travel time will drop to 10 to 12 days as contrasted with the 21 day life estimate for chloramines given above. Adequate chloramine residuals may remain intact, but re-injection, if needed, would be at a limited number of pumping stations. Chlorine on the other hand, with closer to a seven-day life, would require re-injection more frequently, perhaps at as many as 25% of the booster pump stations.

Regional water projects in South Dakota (Mid-Dakota and Mni Wiconi) have converted, at least in part, to chloramines in an effort to maintain residuals and comply with anticipated disinfectant byproduct regulations.

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[48] AWWA RF, August 1999, *How Chloramines Improve Water Quality*, Research Application: Research in Use, p. 2

[49] *Ibid.*

[50] *Ibid*.

EXHIBIT A

NATIONAL PRIMARY DRINKING WATER STANDARDS

http://www.epa.gov/safewater/consumer/mcl.pdf

United States Environmental Protection Agency | Office of Water (4606) | EPA 810-F-94-001 December 1999

National Primary Drinking Water Standards

Contaminant	MCLG[1] (mg/L) [4]	MCL[2] or TT[3](mg/L)[4]	Potential Health Effects from Exposure Above the MCL	Common Sources of Contaminant in Drinking Water
Inorganic Chemicals				
Antimony	0.006	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic	none[5]	0.05	Skin damage; circulatory system problems; increased risk of cancer	Erosion of natural deposits; runoff from orchards; runoff from glass and electronics production wastes
Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	7 MFL	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits
Barium	2	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Beryllium	0.004	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries
Cadmium	0.005	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Chromium (total)	0.1	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	1.3	Action Level=1.3; TT[6]	Short term exposure: Gastrointestinal distress Long term exposure: Liver or kidney damage Those with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives
Cyanide (as free cyanide)	0.2	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories
Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones) Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories
Lead	zero	Action Level=0.015; TT[6]	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (Inorganic)	0.002	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
Nitrate (measured as Nitrogen)	10	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Nitrite (measured as Nitrogen)	1	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Selenium	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	0.0005	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories

Contaminant	MCLG[1] (mg/L) [4]	MCL[2] or TT[3](mg/L)[4]	Potential Health Effects from Exposure Above the MCL	Common Sources of Contaminant in Drinking Water
Organic Chemicals				
Acrylamide	zero	TT[7]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/wastewater treatment
Alachlor	zero	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops
Atrazine	0.003	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops
Benzene	zero	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills
Benzo(a)pyrene	zero	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines
Carbofuran	0.04	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa
Carbon tetrachloride	zero	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities
Chlordane	zero	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide
Chlorobenzene	0.1	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories
2,4-D	0.07	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops
Dalapon	0.2	0.2	Minor kidney changes	Runoff from herbicide used on rights of way
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards
o-Dichlorobenzene	0.6	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories
p-Dichlorobenzene	0.075	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories
1,2-Dichloroethane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
1-1-Dichloroethylene	0.007	0.007	Liver problems	Discharge from industrial chemical factories
cis-1, 2-Dichloroethylene	0.07	0.07	Liver problems	Discharge from industrial chemical factories
trans-1,2-Dichloroethylene	0.1	0.1	Liver problems	Discharge from industrial chemical factories
Dichloromethane	zero	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories
1-2-Dichloropropane	zero	0.005	Increased risk of cancer	Discharge from industrial chemical factories
Di(2-ethylhexyl)adipate	0.4	0.4	General toxic effects or reproductive difficulties	Discharge from chemical factories
Di(2-ethylhexyl)phthal-ate	zero	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories
Dinoseb	0.007	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories
Diquat	0.02	0.02	Cataracts	Runoff from herbicide use
Endothall	0.1	0.1	Stomach and intestinal problems	Runoff from herbicide use
Endrin	0.002	0.002	Liver problems	Residue of banned insecticide
Epichlorohydrin	zero	TT[7]	Increased cancer risk, and over a long period of time, stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals
Ethylbenzene	0.7	0.7	Liver or kidneys problems	Discharge from petroleum refineries

Contaminant	MCLG[1] (mg/L) [4]	MCL[2] or TT[3](mg/L)[4]	Potential Health Effects from Exposure Above the MCL	Common Sources of Contaminant in Drinking Water
Ethylene dibromide	zero	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries
Glyphosate	0.7	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use
Heptachlor	zero	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide
Heptachlor epoxide	zero	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor
Hexachlorobenzene	zero	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories
Hexachloro-cyclopentadiene	0.05	0.05	Kidney or stomach problems	Discharge from chemical factories
Lindane	0.0002	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens
Methoxychlor	0.04	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock
Oxamyl (Vydate)	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes
Polychlorinated biphenyls (PCBs)	zero	0.0005	Skin changes; thymus gland problems; immune difficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfils; discharge of waste chemicals
Pentachlorophenol	zero	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood preserving factories
Picloram	0.5	0.5	Liver problems	Herbicide runoff
Simazine	0.004	0.004	Problems with blood	Herbicide runoff
Styrene	0.1	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills
Tetrachloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners
Toluene	1	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories
Total Trihalomethanes (TTHMs)	none[5]	0.10	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection
Toxaphene	zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
2,4,5-TP (Silvex)	0.05	0.05	Liver problems	Residue of banned herbicide
1,2,4- Trichlorobenzene	0.07	0.07	Changes in adrenal glands	Discharge from textile finishing factories
1,1,1- Trichloroethane	0.20	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories
1,1,2- Trichloroethane	0.003	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories
Trichloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories
Vinyl chloride	zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories
Xylenes (total)	10	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories
Radionuclides				
Beta particles and photon emitters	none[5]	4 millirems per year (mrem/yr)	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation
Gross alpha particle activity	none[5]	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation

Contaminant	MCLG[1] (mg/L) [4]	MCL[2] or TT[3](mg/L)[4]	Potential Health Effects from Exposure Above the MCL	Common Sources of Contaminant in Drinking Water
Radium 226 and Radium 228 (combined)	none[5]	5 pCi/L	Increased risk of cancer	Erosion of natural deposits
Microorganisms				
Giardia lamblia	zero	TT[8]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
Heterotrophic plate count (HPC)	N/A	TT[8]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment
Legionella	zero	TT[8]	Legionnaire's Disease, a type of pneumonia[9]	Found naturally in water; multiplies in heating systems
Total Coliforms (including fecal coliform and *E. coli*)	zero	5.0%[10]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[11]	Total coliforms are naturally present in the environment; fecal coliforms and *E. coli* come from human and animal fecal waste.
Turbidity	N/A	TT[8]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease- causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff
Viruses (enteric)	zero	TT[8]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste

Notes

1 Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

2 Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

3 Treatment Technique (TT) - A required process intended to reduce the level of a contaminant in drinking water.

4 Units are in milligrams per Liter (mg/L) unless otherwise noted.

5 MCLGs were not established before the 1986 Amendments to the Safe Drinking Water Act. The standard for this contaminant was set prior to 1986. Therefore, there is no MCLG for this contaminant.

6 Lead and copper are regulated using a Treatment Technique which requires systems to control the corrosiveness of their water. The action level serves as a trigger for water systems to take additional treatment steps if exceeded in more than 10% of tap water samples. For copper, the action level is 1.3 mg/L, and for lead is 0.015mg/L.

7 Each water system must certify, in writing, to the state that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05% dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent)

8 The Surface Water Treatment Rule requires systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or provide the same level of treatment as those who filter. Treatment must reduce the levels of *Giardia lamblia* (parasite) by 99.9% and viruses by 99.99%. *Legionella* (bacteria) has no limit, but EPA believes that if *Giardia* and viruses are inactivated, *Legionella* will also be controlled. At no time can turbidity (cloudiness of water) go above 5 nephelometric turbidity units (NTU) [systems that filter must ensure that the turbidity is no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples for any single month]; HPC- no more than 500 bacterial colonies per milliliter.

9 Legionnaire’s disease occurs when aerosols containing *Legionella* are inhaled by susceptible persons, not when people drink water containing *Legionella*. (Aerosols may come from showers, hot water taps, whirlpools and heat rejection equipment such as cooling towers and air conditioners.) Some types of *Legionella* can cause a type of pneumonia called Legionnaire’s Disease. *Legionella* can also cause a much less severe disease called Pontiac Fever. The symptoms of Pontiac Fever may include muscle pain, headache, coughing, nausea, dizziness and other symptoms.

10 No more than 5.0% of samples may be total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample may be total coliform-positive during a month). Every sample that has total coliforms must be analyzed for either *E. coli* or fecal coliforms to determine whether human or animal fecal matter is present (fecal coliform and *E. coli* are part of the total coliform group).

11 Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.