3.0 Water Quality

3.1 Water Quality

Water quality of a potential water supply source is an important factor in determining appropriate treatment methods. For this study, it takes on added importance because of concerns related to the legacy of mining in the extreme upper reaches of the Uncompahgre River. Since water quality varies with seasonal flow rates, this study incorporated five-months (April through August) of water quality samples bracketing the snowmelt runoff.

3.1.1 Sample Locations

Samples were collected from three sites to characterize the full spectrum of water quality within Ridgway Reservoir. Samples were collected from the reservoir river inflow, the reservoir surface, and the reservoir lower depths. Figure 3.1 shows the sample locations.

3.1.1.1 Uncompahgre River Sample

The first sample was collected directly from the Uncompahgre River as it enters Ridgway Reservoir. The sample site was at the CR 24 Bridge which is also adjacent to USGS gaging station 09146200. This sample is identified as the “River” sample and represents the general water quality entering Ridgway Reservoir. Dallas Creek, another major tributary of the Uncompahgre River enters Ridgway Reservoir downstream of the sampling location. However, Dallas Creek is considered to generally have superior quality water so the selected site may represent a “worst” case for reservoir inflow.

Samples were collected by lowering a Van Dorn Bottle sampler into the flow stream as visually determined to be half depth. A Van Dorn Bottle sampler is a device made for capturing sample of water at a desired depth without contamination from water above that depth as the sampler descends to the correct depth. The Van Dorn Bottle sampler consists of a hollow cylindrical tube with rubber stoppers at each end. Prior to sampling, the stoppers are restrained in an open position. When the sampler is at the correct depth a period of time is allowed for water at that depth to enter and flush through the tube. Then a brass collar weight is dropped down the line which triggers the release of the stoppers, capturing a sample at the appropriate depth. Several “grab” samples were combined to make a composite sample large enough to fill all the required sample bottles.

3.1.1.2 Ridgeway Reservoir Near Surface Sample

The second sampling site is within Ridgway Reservoir and represents the near surface water quality conditions within the reservoir. The site is located immediately above the reservoir outlet works intake and 4-meters (approximately 12-ft) below the water surface. The specific coordinates are N38°14.174' latitude and W107°45.405' longitude as measured by a handheld GPS unit.

A small John Boat was used to navigate to the sample waypoint as set by the above GPS coordinates. As with the river sample, the Van Dorn Bottle sampler was lowered to 4-meters below the surface and triggered to capture the sample. This was repeated until the required sample volume was collected.

3.1.1.3 Ridgeway Reservoir Outlet Works Sample

The third and final sampling site is taken from the Ridgway Dam outlet works. The sampling tap within the Access Control Building was used to collect a sample. The water is withdrawn from the reservoir via the outlet works intake located approximately 150-ft below the normal water surface. Prior to sampling, the tap was flushed for several minutes to displace the volume of water in the 2-inch pipe. After flushing enough water was collected in a plastic bucket to fill the required sample bottles.

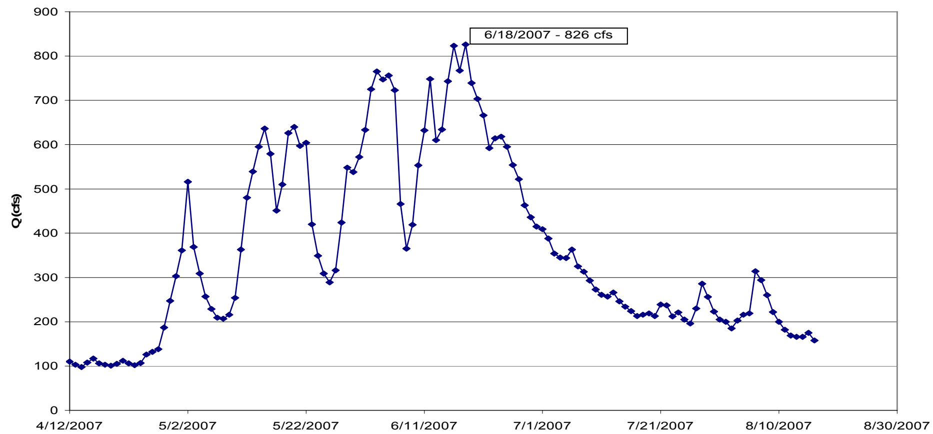
3.1.2 Sampling Period

Table 3-1 summarizes information from the sampling program. Samples were collected over a five month period beginning in April 2007 and ending in August 2007. The period was selected to encompass the spring runoff hydrograph which was accomplished. The chart following Table 3-1 shows the daily average flows during the sampling period. The peak daily runoff during the sampling period was 826-cfs.

Table 3-1

Summary of Sample Collection Data

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Date	4/12/07	5/15/07	6/12/07	7/16/07	8/13/07
Time of Day	morning	morning	morning	morning	morning
Air Temperature, °F	31 to 38	64-67	50-53	75-85	77-84
Weather	light snow	clear	rain	clear	clear
River Flow, cfs	110	636	748	224	166
Reservoir Stage, ftMSL	6867.2	6861.57	6866.24	6865.56	6856.48
Reservoir Release, cfs	225	400	600	550	450



Appendix A includes the detailed sample collection logs for each sampling period.

3.1.3 Sample Preparation and Analysis

Prior to each sampling period, Analytica Environmental Laboratories of Thornton, Colorado provided a cooler with the required number of sample bottles each preserved as required. The Ridgway Dam staff filled out the labels for each sample bottle and froze the chemical ice packs. Table 3-2 provides information on the sampling bottles, preservatives, and tests conducted on each sample. There were separate sets of sample bottles provided for each sample location.

Table 3-2

Sample Preparation

Analysis	Sample Size	Bottle	Preservative
Total Metals, Total Hardness	1-liter	Poly	Nitric
Total Cyanide	1-liter	Poly	NaOH/Ascorbic Acid
Fl, Chloride, Nitrate, Sulfate, Alkalinity	500-ml	Poly	None
TOC	250-ml	AG	HCl
DOC[1]	250-ml	AG	HCl
UVA-254	250-ml	AG	None
pH, TSS, TDS, Turbidity	1-liter	Poly	None
NH4-N	500-ml	Poly	Sulfuric

[1]The DOC sample was collected in an unpreserved 500-ml Poly bottle and then filtered using 25-mm diameter, 45-µm pore size Whatman filters before depositing the sample in the preserved container.

Following collection, the sample bottles were packed into the cooler using the frozen chemical packs and shipped via Fed-Ex overnight priority mail to the Analytica Laboratory in Thornton, Colorado.

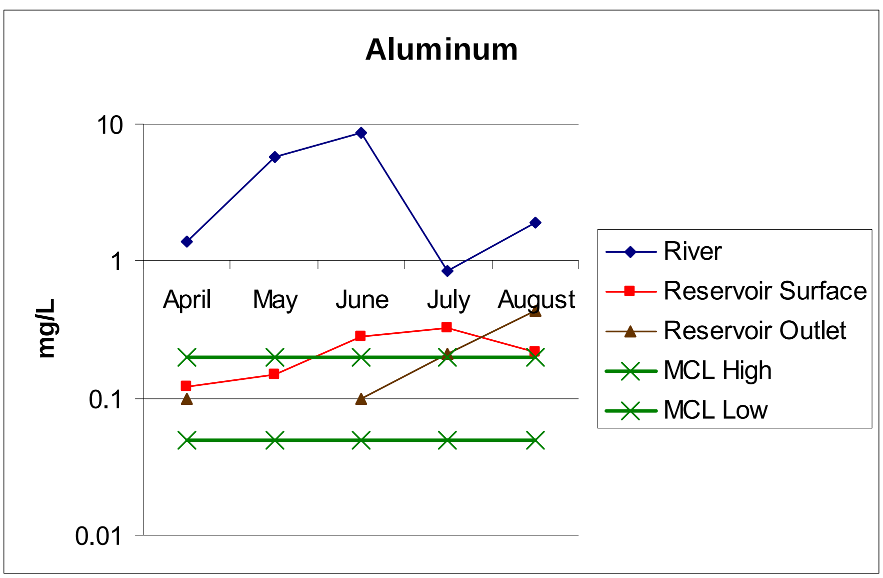
3.1.4 Inorganic Parameters - Metals

A full range of inorganic constituents including all major metals was analyzed for each sample. It should be noted, that no constituents were detected in quantities that would render any of the sampling sites unsuitable for a water supply. While generally of poorer water quality than the reservoir samples, the river samples were adequate for water supply. Fears associated with the mining legacy appear unfounded based on the results of our complete testing program.

3.1.4.1 Aluminum

Aluminum is the third must abundant element, and the most abundant within the earths crust. It is most commonly found as aluminosilicates such as clay, mica, and feldspar. The health effects of aluminum are not fully understood, but large doses are thought to result in gastrointestinal irritation. Some speculate that high doses of aluminum may be a causative effect for Alzheimer's disease. High concentrations of aluminum also result in discoloration of the water supply.

The secondary drinking water standards limit the Maximum Contaminant Level (MCL) of aluminum in finished water to 0.05-mg/l to 0.2-mg/l. Secondary drinking water standards are guidelines based on potential cosmetic, taste or odor concerns and are not legally enforceable. There is no applicable Colorado CDPHE stream standard.

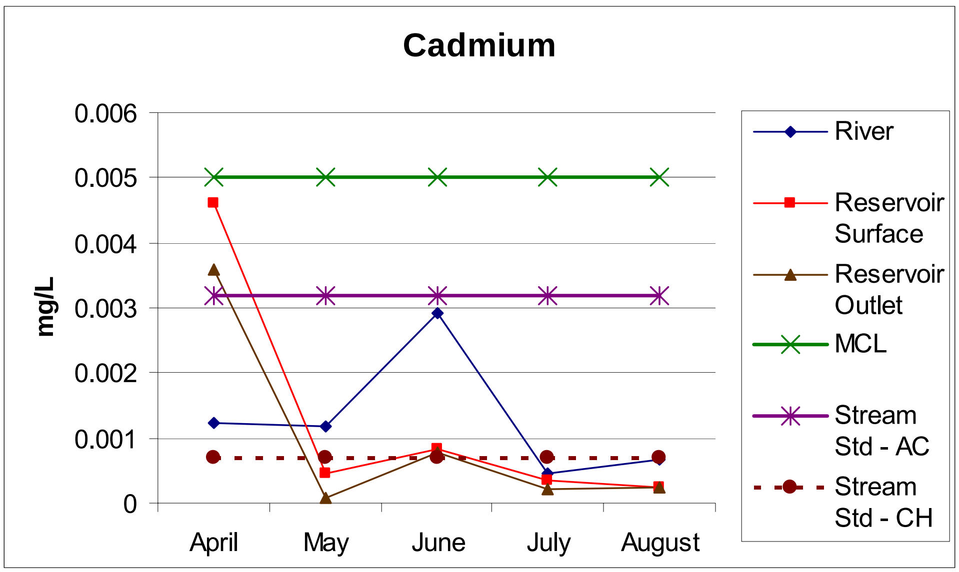


The River samples had extremely high aluminum levels. While less than the river samples, several of the Reservoir Surface (three) and the Reservoir Outlet (two) exceeded the secondary MCL.

3.1.4.2 Cadmium

Cadmium is a naturally occurring metal in rocks, coal and petroleum. It is more commonly found in groundwater supplies, and in surface waters affected by mining and petroleum extraction. In finished water it may be leached from galvanized pipe. No health effects are expected at levels below 15-mg/l. Higher levels may result in renal failure.

The drinking water standards limit the Maximum Contaminant Level (MCL) of cadmium in finished water to 0.005-mg/l. The applicable Colorado CDPHE stream standards are 0.0032-mg/l for acute exposure and 0.0007-mg/l for chronic exposure.



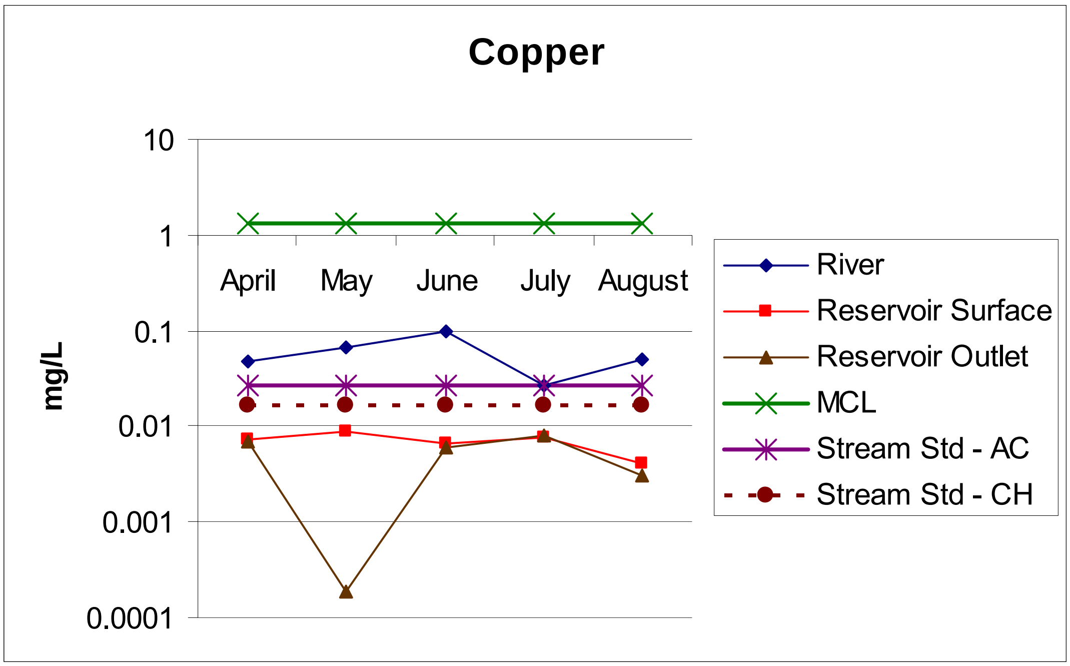
All samples were below the MCL. The Reservoir Surface and Reservoir Outlet samples exceeded the acute stream standard in April, but were below the chronic stream standard for all other samples. The River sample was always below the acute stream standard, but exceeded the chronic stream standard for April through June. The final two River samples (July and August) were below the chronic stream standard.

The sample results probably indicate the results of historic mining activity in the basin, but do not present any limitations on water supply.

3.1.4.3 Copper

Copper is a common element associated with metallic ores. It is commonly found as sulfides and oxides of complex ores. Surface waters generally have less than 0.02-mg/l. It is most commonly found in finished water as a result of corrosion of brass and copper plumbing. Copper is both an essential for human nutrition at low concentrations and a chronic toxin at very high levels.

The primary drinking water standards limit the Maximum Contaminant Level (MCL) of copper in finished water to 1.3-mg/l. A secondary drinking water standard of 1.0-mg/l is established to prevent “green water: stains as a reaction with soap. The applicable Colorado CDPHE stream standards are 0.0269-mg/l for acute exposure and 0.0168-mg/l for chronic exposure.



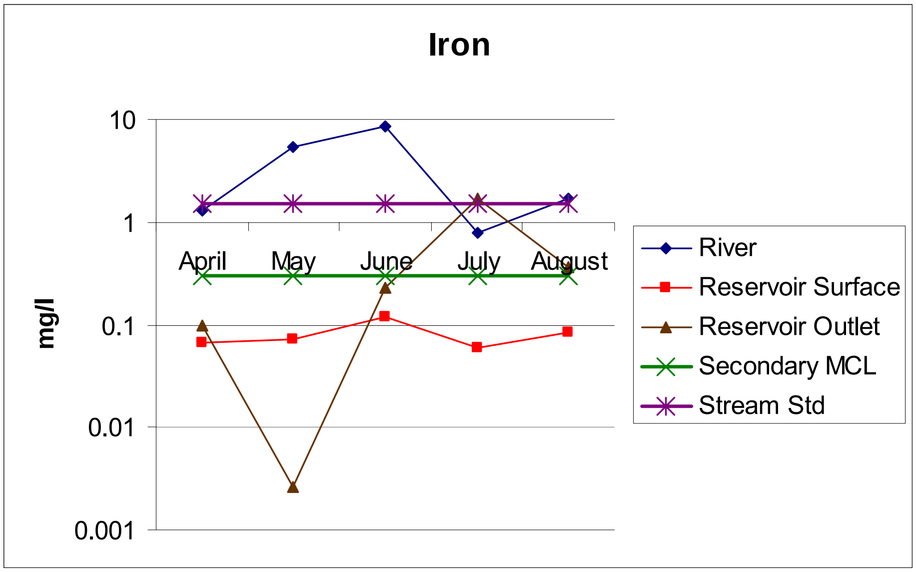
All samples were well below both the primary and secondary drinking water standards. The River samples were all above both the chronic and acute stream standard. All of the Reservoir Surface and Reservoir Outlet samples were below the chronic stream standard.

Like Cadmium, the sample results probably indicate the results of historic mining activity in the basin, but do not present any limitations on water supply.

3.1.4.4 Iron

High concentrations of iron cause fouling of membranes which decreases the time between backwashes, increases the frequency of clean-in-place and shortens the life of the membrane. High levels of iron require pretreatment before membrane treatment.

The secondary drinking water standards recommend that the Maximum Contaminant Level (MCL) of iron in finished water be limited to 0.3-mg/l. Secondary treatment standards are guidance levels based on aesthetics, taste, odor, etc,, and not strict regulatory guidance. In the case of iron, levels above the secondary MCL can result in "red water" problems and staining of plumbing fixtures. The applicable Colorado CDPHE stream standard is 1.5-mg/l.



The River samples were generally above both MCL and stream standards. Therefore, a membrane treatment system using the River source would most likely require provisions for iron removal via chemical oxidation or aeration ahead of the membranes.

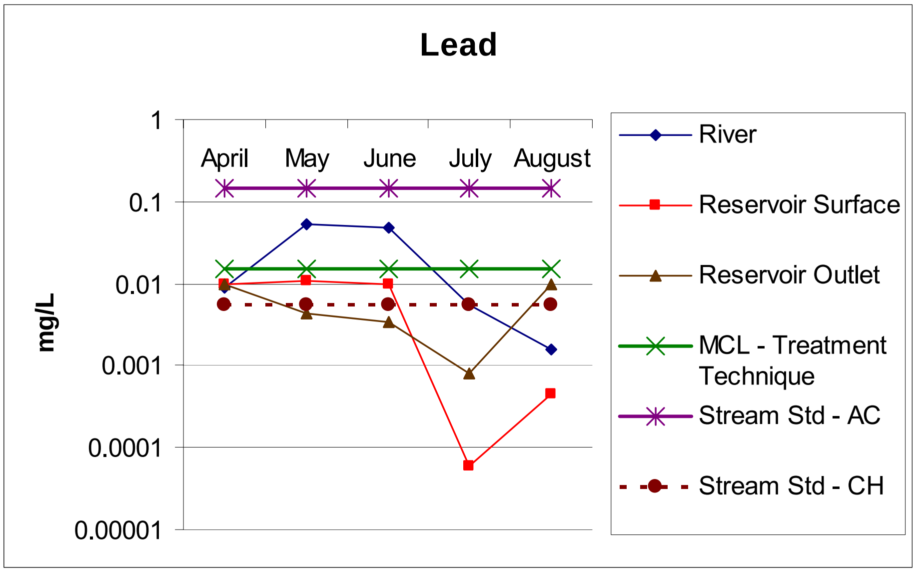
The Reservoir Surface sample had the overall highest water quality consistently meeting both the MCL and stream standards.

The Reservoir Outlet sample had an elevated iron level in July. However, even the level measured is low enough that membrane fouling should not be an issue. The treatment process should remove enough iron that meeting the finished water MCL is not a problem.

3.1.4.5 Lead

Lead is an industrial metal used in storage batteries, radian shields, and other products. Because of concerns with blood lead poisoning, its use in commercial products has been severely restricted. Even relatively low blood lead levels in children can result in mental retardation and irreversible brain damage. Lead in surface water results from leaching from mountain limestone (containing lead ores) and galena formations. Lead is more commonly found in finished water as a result of leaching from lead service lines and plumbing fixtures.

The Maximum Contaminant Level Goal (MCLG) for lead is zero. The primary drinking water standards limit the Maximum Contaminant Level (MCL) of lead in finished water to 0.015-mg/l as a treatment technique action level. At finished water lead levels above the MCL action level, a water system must implement lead controls such as replacement of lead surface lines or lead sequestration via water chemistry (deposition of protective coating). The applicable Colorado CDPHE stream standards are 0.143-mg/l for acute exposure and 0.00556-mg/l for chronic exposure.



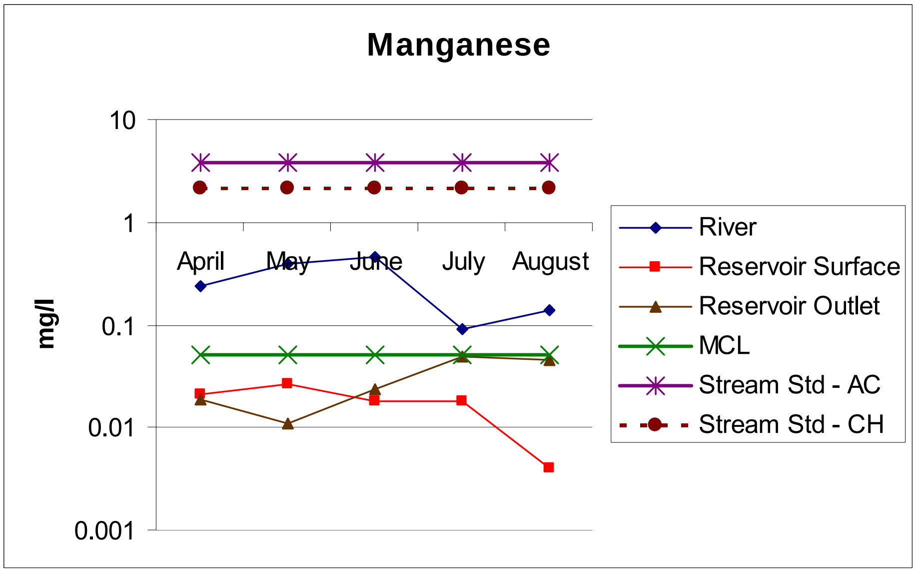
All of the Reservoir Surface and Reservoir Outlet samples were below the drinking water standard action level. The River samples were below the acute stream standard for all samples, but at or above the chronic stream standard for April through July. The Reservoir Surface samples were above the chronic stream standard for April through June, but were below the standard in July and August. The Reservoir Outlet sample was above the chronic stream standard in April, but below the standard for all other months.

3.1.4.6 Manganese

Manganese is another metal associated with membrane fouling, purple water, and metallic taste in treated waters. Like iron, high levels in raw water cause fouling of membranes which decreases the time between backwashes, increases the frequency of clean-in-place and shortens the life of the membrane. High levels of manganese require pretreatment before membrane treatment.

The drinking water standards limit the Maximum Contaminant Level (MCL) of manganese in finished water to 0.05-mg/l. The applicable

Colorado CDPHE stream standard is 3.187-mg/l for acute exposure and 2.109-mg/l for chronic exposure.

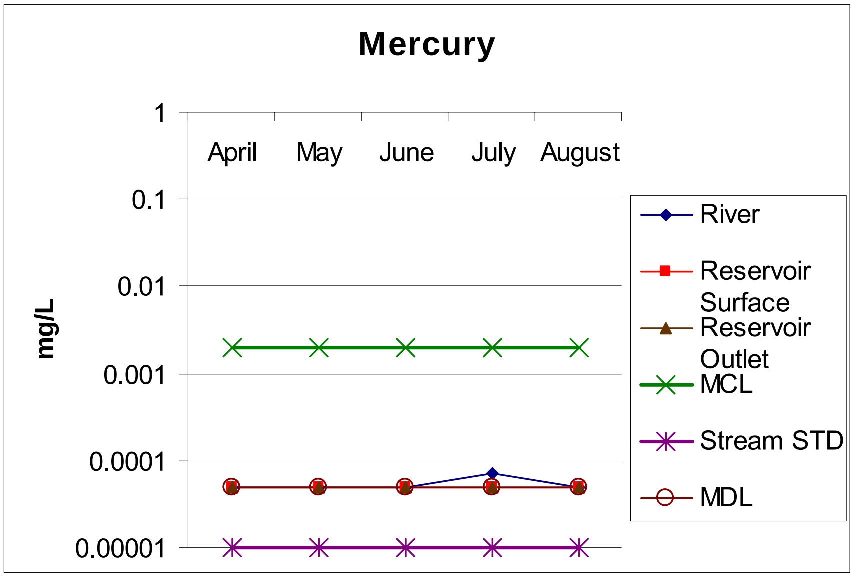


The River sample generally exceeded the MCL but was always below even the chronic stream standard. The Reservoir Surface and Reservoir Outlet samples were always at, or below, the MCL.

3.1.4.7 Mercury

Elemental mercury is a heavy metal that is liquid at room temperatures. It is usually found in nature as a compound with sulfur or in organic compounds as methyl mercury. It bioaccumulates in fish and can be toxic at high levels. High levels of inorganic mercury affect the kidneys and causes neurological degradation. Methyl mercury is very toxic to the central nervous system. Mining, smelting and fossil fuel combustion are the major sources of mercury.

The drinking water standards limit the Maximum Contaminant Level (MCL) of mercury in finished water to 0.002-mg/l. The applicable Colorado CDPHE stream standard is .00001-mg/l which is below the detection limit of 0.0005-mg/l used in this study.

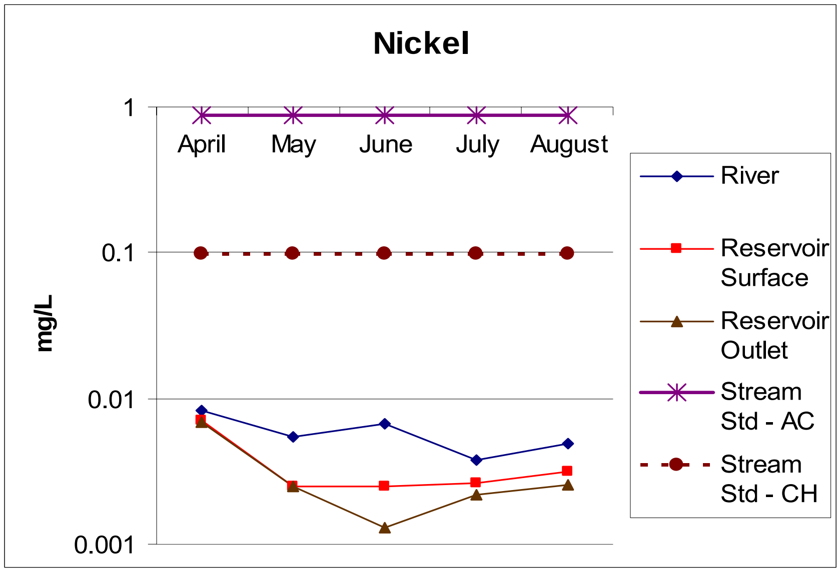


All samples were almost two levels of magnitude less than the MCL. Only one sample (July River sample) was above the detection limit. Since the minimum detection limit is above the stream standard, no conclusions can be drawn regarding meeting the stream standards other than that the July River sample did exceed the stream standard.

3.1.4.8 Nickel

Nickel is an industrial metal used in the making of stainless steel. It is an essential nutrient for animals, but human nickel deficiency has not been recognized.

EPA briefly listed a drinking water standard Maximum Contaminant Level (MCL) of nickel in finished water at 0.1-mg/l. Subsequent final standards eliminated Nickel form the list. Therefore, there is no current MCL in either the primary or secondary drinking water standards. The applicable Colorado CDPHE stream standard is 0.8737-mg/l for acute exposure and 0.0971-mg/l for chronic exposure.

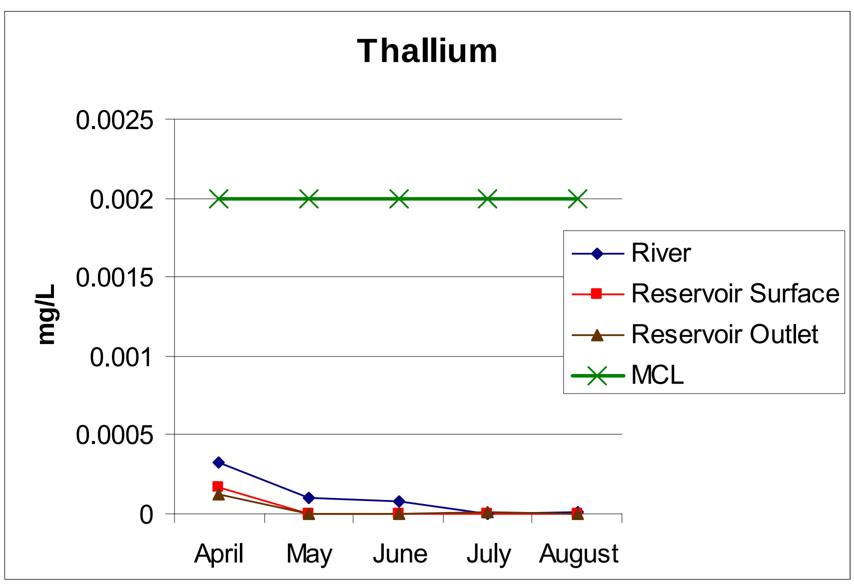


All samples from all locations were below the chronic stream standard.

3.1.4.9 Thallium

Thallium is a rare heavy metal used I photocells, and prior to 1975 in rodentcides and ant killers. It is a suspected carcinogen in humans. Its principal source is leaching from ore processing sites, particularly lead and zinc.

The drinking water standards limit the Maximum Contaminant Level (MCL) of thallium in finished water to 0.002-mg/l. There are no applicable Colorado CDPHE stream standards.



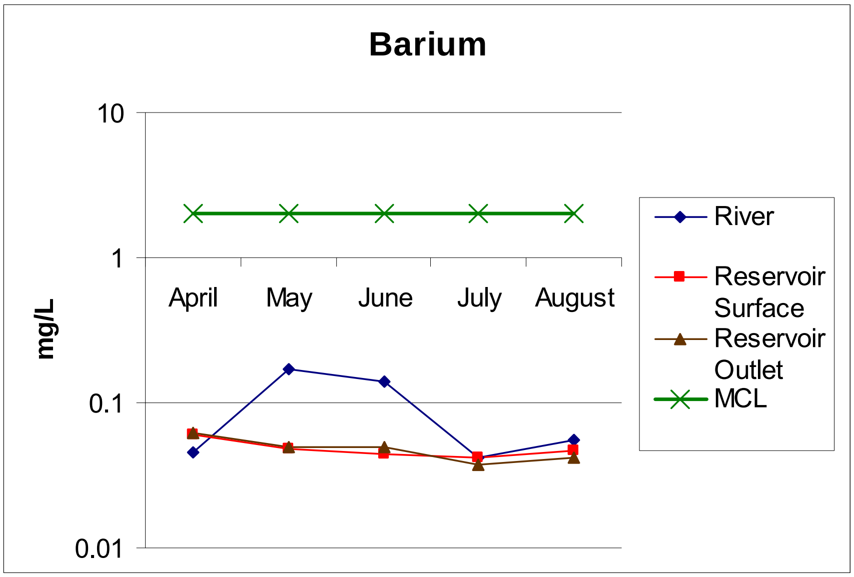
All samples from all sites were well below the MCL.

3.1.5 Inorganic Parameters – Alkaline Earths

3.1.5.1 Barium

Barium is an abundant element found in carbonates and sulfates. When found in surface waters, it usually is the result of mining and/or petroleum extraction. High barium exposure is linked to high blood pressure and cardiotoxicity.

The drinking water standards limit the Maximum Contaminant Level (MCL) of barium in finished water to 2.0-mg/l. There are no applicable Colorado CDPHE stream standards.

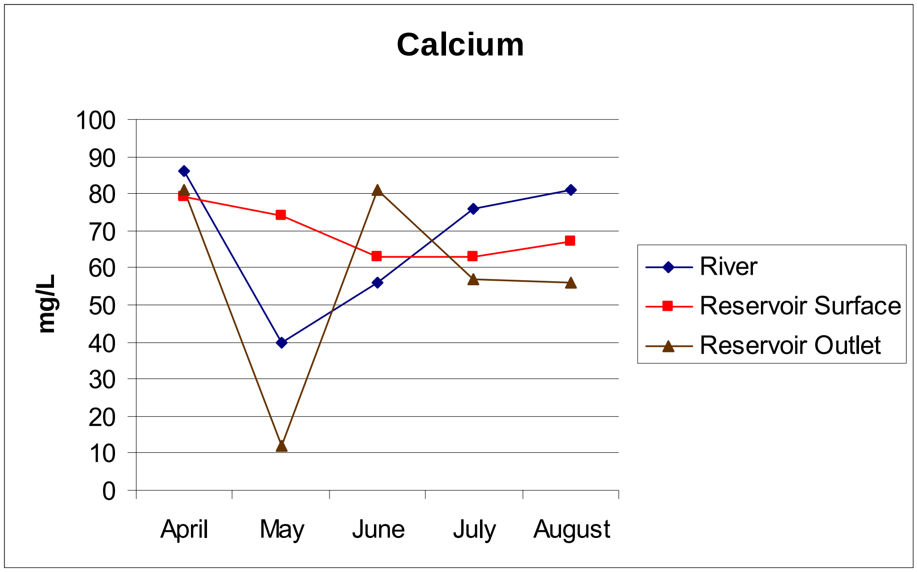


All samples at all sites were at least an order of magnitude below the MCL.

3.1.5.2 Calcium

Calcium is the fifth most abundant element. It is an essential element for bones and teeth. There are no special health concerns other than that very high levels are a suspected cause of increased development of bladder and kidney stones. Its importance to the water industry is related to the hardness of the water. Calcium and Magnesium are the two major ions that produce hard water. The generally accepted dividing line between hard and soft water is 75-mg/l.

While EPA does not regulate calcium, the Word Health Organization (WHO) recognizes 200-mg/l as an excessive upper limit. There are not stream standards for calcium.

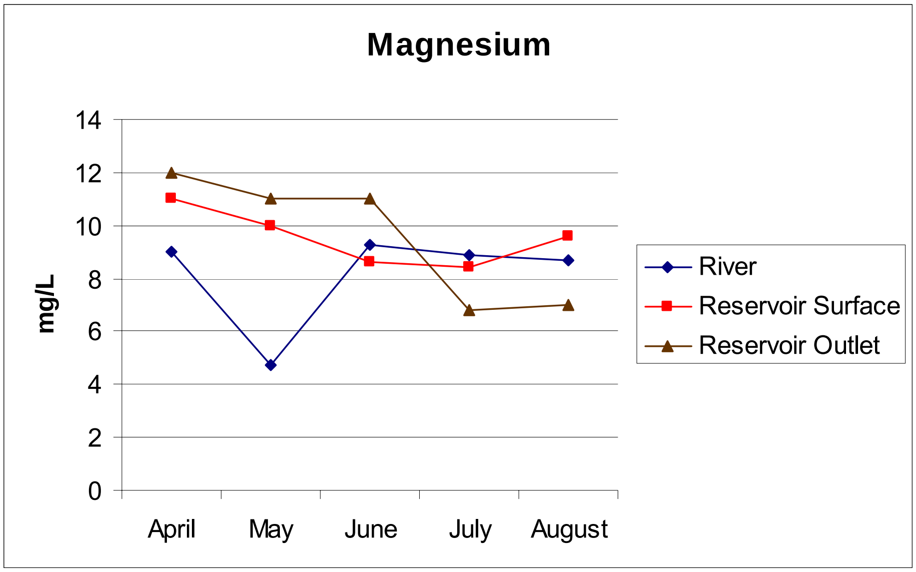


Approximately 40-percent of the samples were above the 75-mg/l dividing line between hard and soft water. Even the values above 75-mg/l were low enough that the samples are only moderately hard. All samples are low enough that water softening would not be required and no special concerns with any treatment technique would be required.

3.1.5.3 Magnesium

Magnesium is the eighth most abundant element. It is an essential nutritional element. There are no special health concerns other than that very high levels have a laxative and diuretic effect. In conjunction with calcium its importance to the water industry is related to the hardness of the water and taste.

While EPA does not regulate magnesium, the Word Health Organization (WHO) recognizes 150-mg/l as an excessive upper limit. There are not stream standards for calcium.



All samples were well below any threshold for concern, and in conjunction with the calcium levels do not result in excessively hard water.

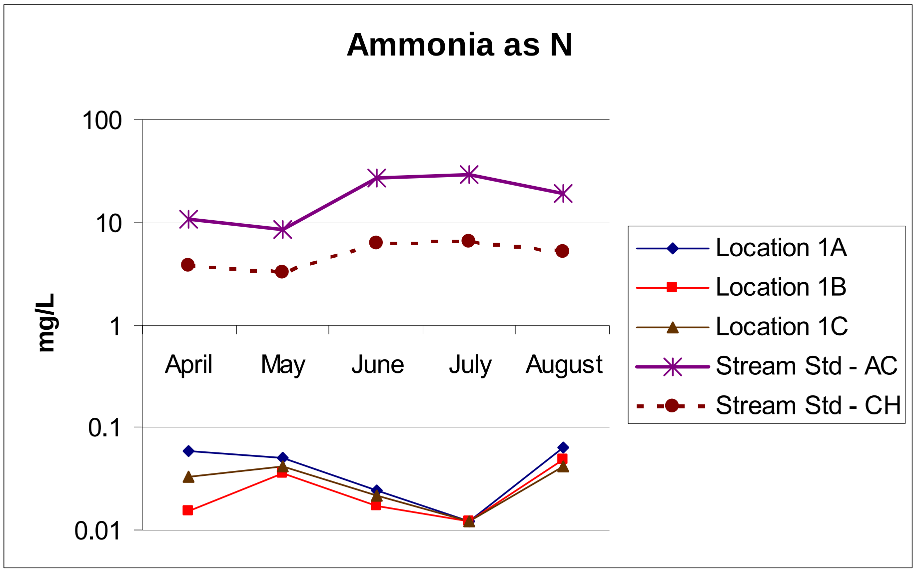
3.1.6 Inorganic Parameters – Other

3.1.6.1 Ammonia

Ammonia is a reduced form of nitrogen in combination with hydrogen. It is commonly presented as its equivalent weight as nitrogen – ignoring the hydrogen atoms. Ammonia is a byproduct of organic decay and is present in raw wastewaters and some wastewater treatment plant effluents (specifically those that do not have ammonia limits that require nitrification). High ammonia levels in raw water supplies may indicate effluent dominated streams, or highly organic supply (e.g. swamp water).

There are no primary or secondary drinking water standards for ammonia, and in the concentrations found in typical raw waters there are no adverse health effects. Ammonia may be added to treated water to combine with chlorine and form chloramines, a long lasting and stable disinfectant.

While not a health issue for humans, ammonia is very toxic to fish, particularly salmonids (trout). The acute toxicity is a function of pH and the chronic toxicity is a function of both pH and temperature. Additionally, the chronic criteria is based on the presence or absence of juvenile salmonids. In the table below, the acute and chronic stream standards are based on the new AMTOX model and adjusted for the average pH and temperature of the samples for each month (technically there would be a separate standard for each site because of varying pH and temperature between the three sampling sites).

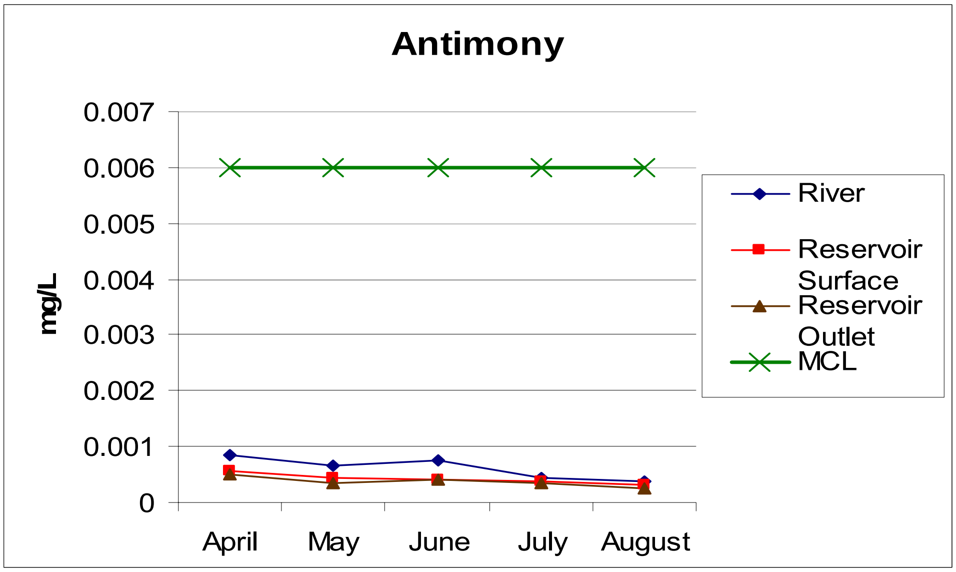


All samples were well below the chronic stream standard and low enough that the stream does not exhibit any characteristics of high organic content or effluent dominance.

3.1.6.2 Antimony

Antimony is a rare element found in some sulfides. The adverse health effects of antimony include an increase in blood cholesterol and a decrease in blood sugar.

The drinking water standards limit the Maximum Contaminant Level (MCL) of antimony in finished water to 0.006-mg/l. There are no applicable Colorado CDPHE stream standards.

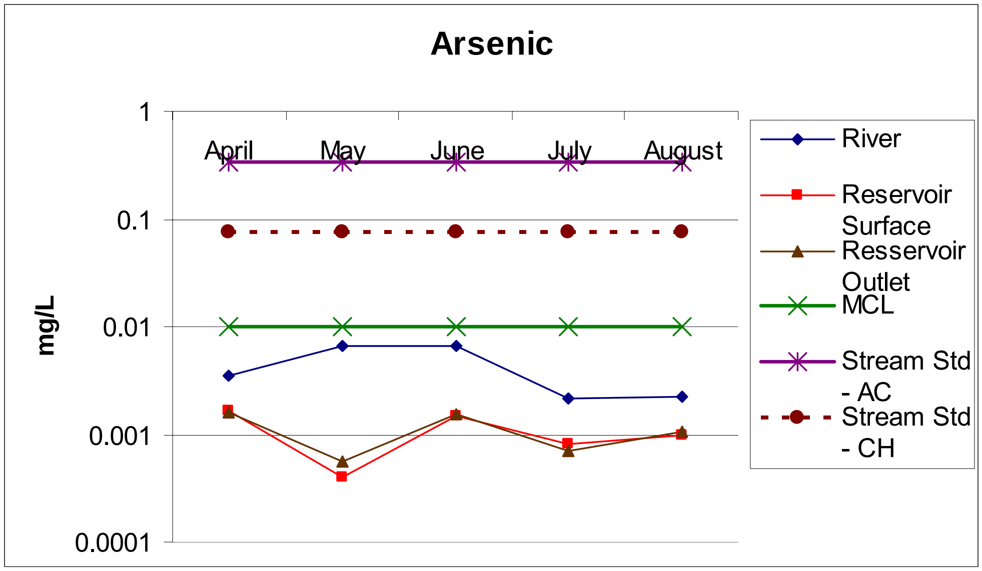


All samples were nearly an order of magnitude lower than the MCL.

3.1.6.3 Arsenic

Arsenic is an acute human toxin. It expected to bioaccumulate and has been reported poisonous at concentrations as low as 0.21-mg/l. Its carcinogenetic properties are still being debated, but it has known detrimental effects on skin, lungs, genitals, and eyes at low levels. Arsenic may be found in groundwater from native rock composition and in surface waters as a by-product of smelting operations.

The drinking water standards limit the Maximum Contaminant Level (MCL) of arsenic in finished water to 0.01-mg/l. The applicable Colorado CDPHE stream standard is 0.34-mg/l for acute exposure and 0.076-mg/l for chronic exposure.

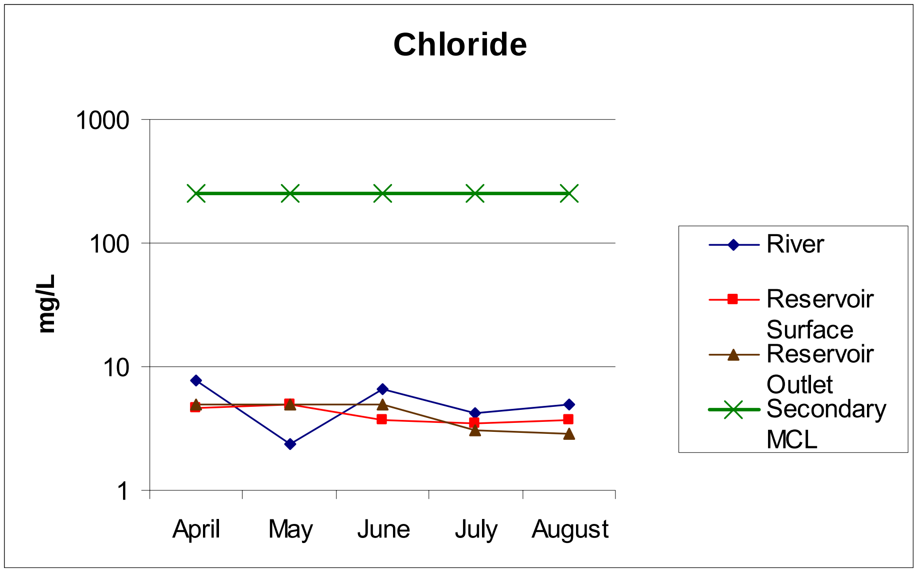


.All samples were below the MCL and well below the chronic stream standards.

3.1.6.4 Chlorides

Chlorides are compounds of chlorine. They occur naturally at low levels in fresh water. The presence of chlorides above 10-mg/l usually indicates a pollution source such as wastewater effluent or road deicing salts.

The secondary drinking water standards recommend that the Maximum Contaminant Level (MCL) of chloride in finished water be limited to 250-mg/l. Secondary treatment standards are guidance levels based on aethetics, taste, odor, etc,, and not strict regulatory guidance. In the case of chloride, levels above the secondary MCL can result in taste problems and toxicity in fresh water aquariums. There are no applicable Colorado CDPHE stream standards.

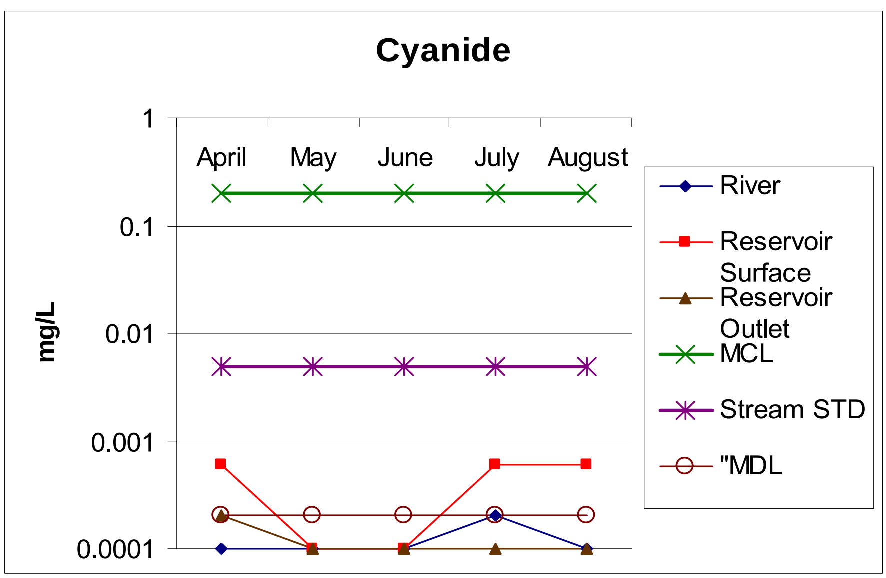


All samples were below 10-mg/l indicating that any contamination for a pollution source is unlikely.

3.1.6.5 Cyanide

Cyanide is an acute human toxin. It is a compound of one atom or nitrogen and one atom of carbon. It rarely occurs in nature and is byproduct of some smelting operations. The lungs, gastrointestinal tract and skin absorb cyanides.

The drinking water standards limit the Maximum Contaminant Level (MCL) of cyanide in finished water to 0.20-mg/l. The applicable Colorado CDPHE stream standard is 0.005-mg/l for both acute and chronic exposure.

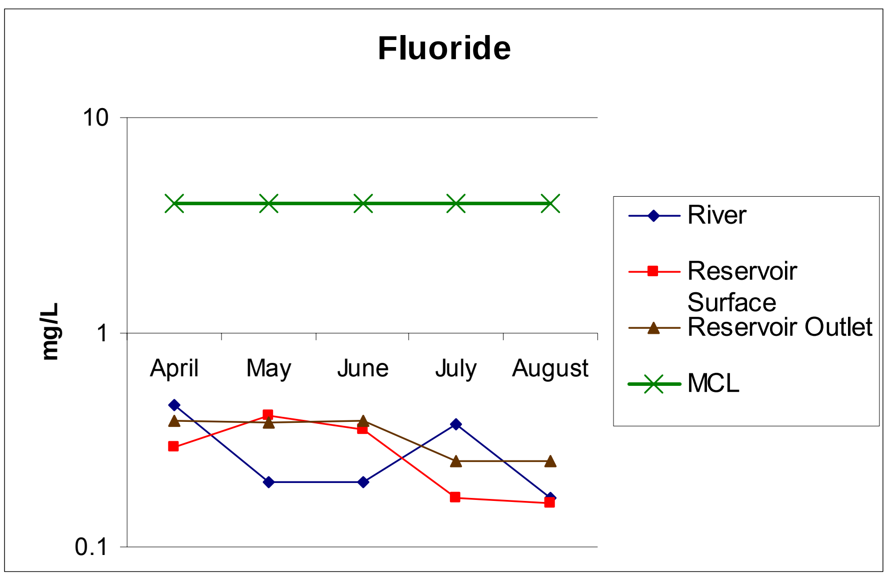


Two-thirds of the samples analyzed were below the minimum detection limit. Of those samples which contained cyanide, the results were nearly an order of magnitude below the stream standards.

3.1.6.6 Fluoride

Fluoride is a halogen that has both beneficial and detrimental affects. It occurs naturally in some rock formations. At low doses (0.8-1.0-mg/l) it is considered beneficial to dental protection and is often added to water supplies (as is the case with Project 7's water) as a prophylactic to prevent dental caries. At high levels (1-2mg/l), fluoride causes dental fluorosis, or mottled teeth.

The secondary drinking water standards recommend that the Maximum Contaminant Level (MCL) of fluoride in finished water be limited to 2.0-mg/l. Secondary treatment standards are guidance levels based on aesthetics, taste, odor, etc,, and not strict regulatory guidance. In the case of fluoride, levels above the secondary MCL can result dental fluorosis. There are no applicable Colorado CDPHE stream standards.

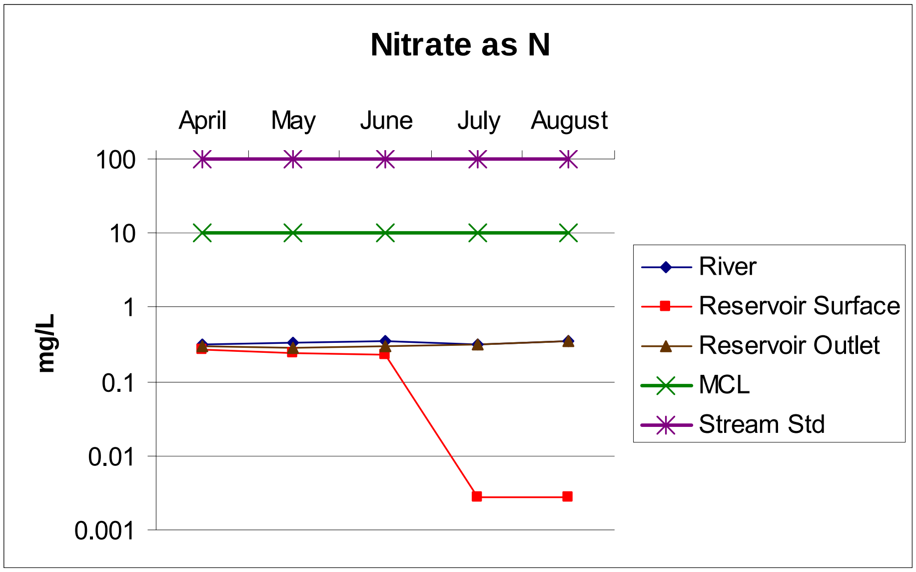


All samples were below the MCL and below the recommended dose for prophylactic protection of dental caries. Supplemental fluoride would need to be added as part of the treatment process.

3.1.6.7 Nitrate

Nitrate is the end form of the oxidation of organic nitrogen and ammonia. The gastrointestinal tract of infants reduces 100% of ingested nitrate to nitrite. Nitrite is a health hazard at concentrations above 10-mg/l and causes methemoglobinemia (blue baby syndrome) in infants. Therefore, to prevent reduction to nitrite, nitrate should also be limited to 10-mg/l. Sources of nitrate include fertilizers and wastewater effluent from facilities with strict ammonia limits that have required nitrification to prevent ammonia toxicity in the discharge. Source water with nitrate levels below 2-mg/l are generally considered high quality sources.

The drinking water standards limit the Maximum Contaminant Level (MCL) of nitrate in finished water to 10--mg/l. The applicable Colorado CDPHE stream standard is 100-mg/l for both acute and chronic exposure.

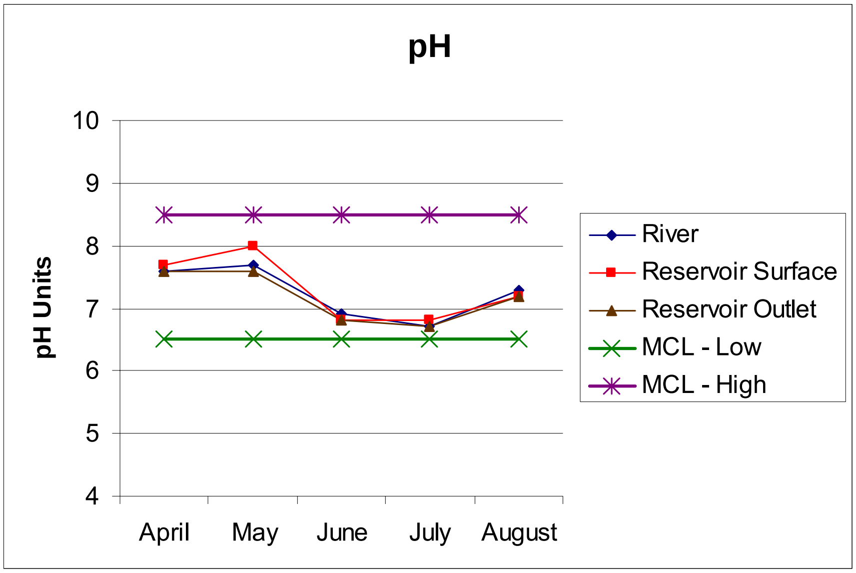


All samples form all sites had very low nitrate concentrations.

3.1.6.8 pH

A waters pH indicates its relative position as an acid or base. Most surface waters are “neutral” pH which means around a value of 7.0. Lower pH readings indicate acidic conditions and higher pH readings indicate a basic, or alkaline, condition. pH is related to the alkalinity and hardness of water and its inherent buffering capacity.

The MCL for pH requires that the water be between 6.5 and 8.5 ph units.

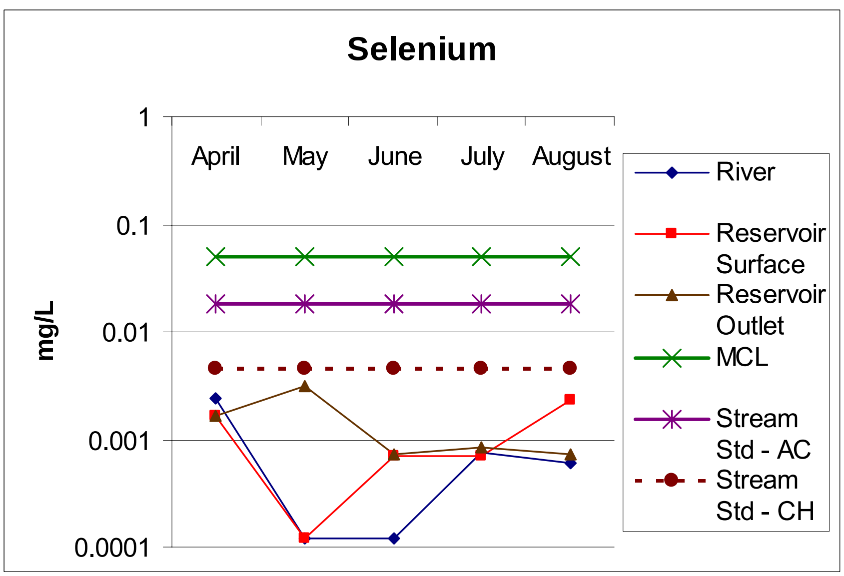


All samples at all sites were within the MCL limits.

3.1.6.9 *Selenium*

Selenium is an element of the Sulphur family. Selenium is an essential nutrient at low levels and toxic at high doses. Lower doses in animals cause congenital muscle disease. Selenium naturally occurs in most shale, and anthropocentrically as a byproduct of copper ore recovery.

The drinking water standards limit the Maximum Contaminant Level (MCL) of selenium in finished water to 0.05-mg/l. The applicable Colorado CDPHE stream standard is 0.0184-mg/l for acute exposure and 0.0046-mg/l for chronic exposure.

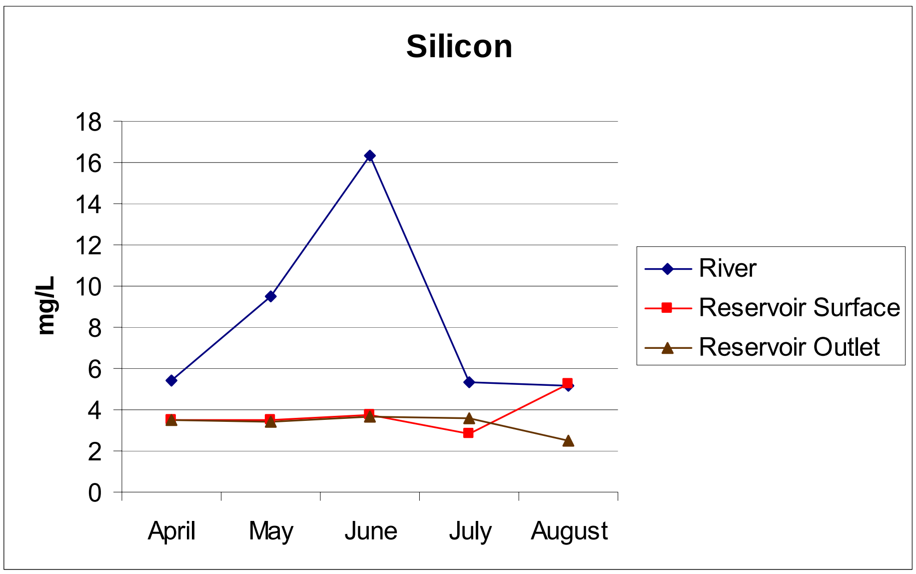


All samples from all sites were in low levels below the chronic stream standard.

3.1.6.10 Silica (Silicon)

Silica is the second most abundant element. It is the predominate element in most igneous minerals. There are no health or environmental effects associated with common levels of Silica. Silica concentration is unimportant in conventional water treatment. However, at high levels, silica polymerizes on membrane surfaces and can reduce membrane flux rate and increase cleaning frequency. Concentrations of 65-mg/l were reported to cause problems in an Australian membrane water treatment plant.

There are no drinking water standards or stream standards for silica.

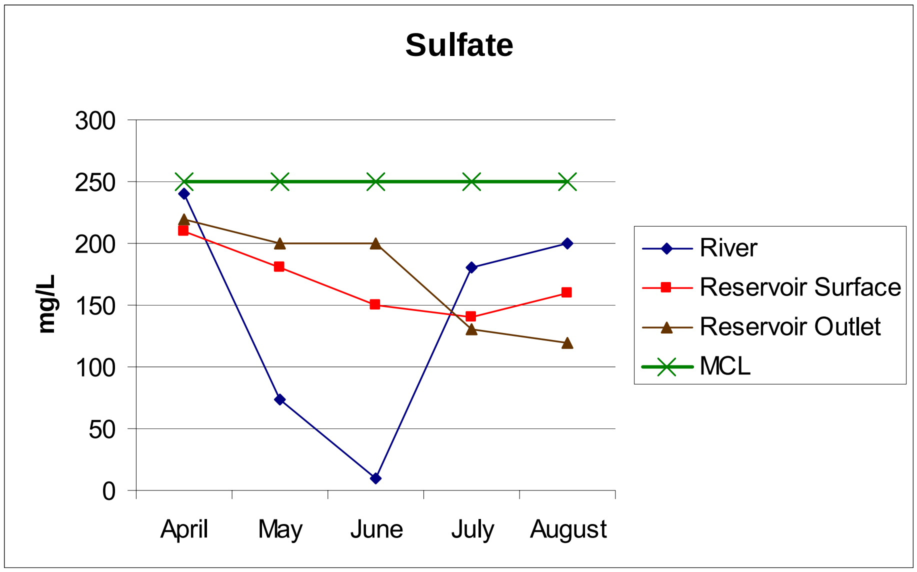


All samples were below levels that could cause concern with membrane treatment.

3.1.6.11 Sulfate

Sulfates are the oxidized end products of sulfides, sulfites, thiosufates, and organic sulfur. They are produced as a byproduct of mining and industrial processes and to a lesser extent in wastewater effluents. High levels of sulfates (generally above 500-mg/l) may cause diarrhea and dehydration. Taste threshold has been reported as low as 200-mg/l but more commonly between 300 and 400-mg/l.

The secondary drinking water standards recommend that the Maximum Contaminant Level (MCL) of sulfate in finished water be limited to 250-mg/l. Secondary treatment standards are guidance levels based on aesthetics, taste, odor, etc,, and not strict regulatory guidance. In the case of sulfate, levels above the secondary MCL can result in taste and odor as noted above. There are no applicable Colorado CDPHE stream standards.



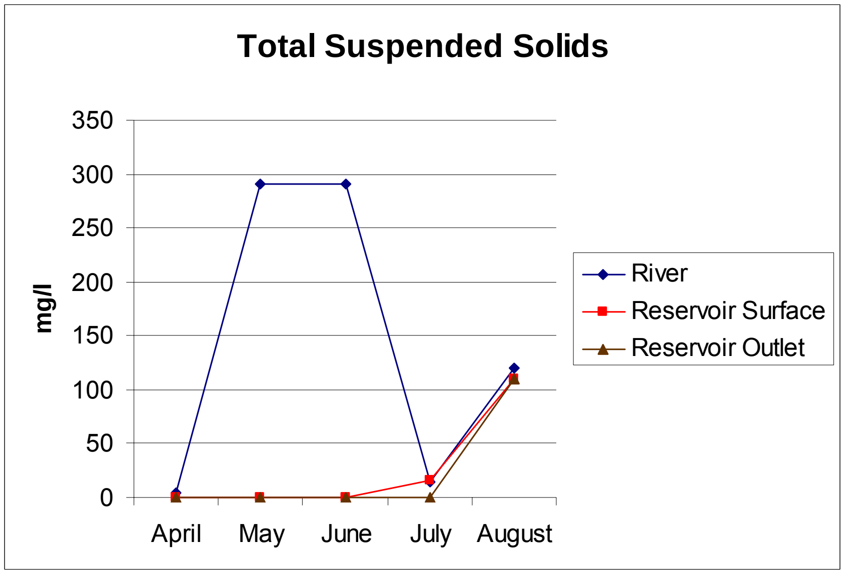
All samples from all sites were below the MCL. The River site exhibited decreasing levels with increased flow indicating a constant mass source of sulfate within the watershed.

3.1.7 Physical Parameters

3.1.7.1 Total Suspended Solids

Total Suspended Solids, TSS indicates the amount of suspended material that must be removed through treatment. It can generally be thought of as the “mud” in the water. There are no specific MCLs or stream standards for TSS. Almost all water treatment processes are very effective at removing TSS. However, higher TSS values result in more residual solids that must be disposed of. Additionally, very high (>100-mg/l) can impact membrane flux rate (the rate at which water travels through the membrane). At the very least, membrane treatment of high TSS water requires more frequent backwashing.

Conversely, very low TSS waters sometimes present a problem for conventional water treatment processes such as coagulation, flocculation and settling. The absence of TSS to serve as a nucleolus for particle agglomeration results in “pin-point” and poor settling floc.

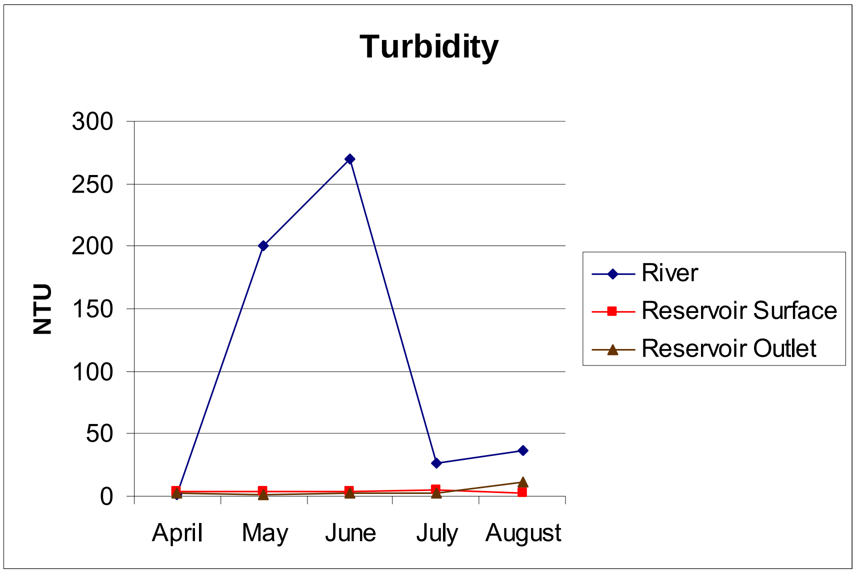


As expected, the River sample showed significant increase in TSS associated with the Spring runoff event. All of the reservoir samples (both surface and outlet) exhibited very low TSS values accept for the August values that indicated a significant spike.

3.1.7.2 Turbidity

Turbidity is a measure of the clarity of water. It is loosely correlated to total suspended solids. The quality of finished water and the performance of filtration is related to turbidity. While there are no turbidity limits for raw water (so none plotted on the graph below), finished water turbidity must be less than 0.3-NTU in 95% of samples. Increased turbidity in raw water usually requires increased chemical use for coagulation, increased residuals production, and shortened filter runs. In membrane treatment, prolonged periods of high turbidity can lower membrane life, lower flux rates and increase the need for backwashing and membrane cleaning.

There are no drinking water standards or stream standards for turbidity in raw water.



The River sample turbidity increased with increasing runoff as one would expect. The Reservoir Surface and Reservoir Outlet samples were all generally very low except for an increase in August (as noted for TSS above).

3.1.8 Organic and Organic Related Parameters

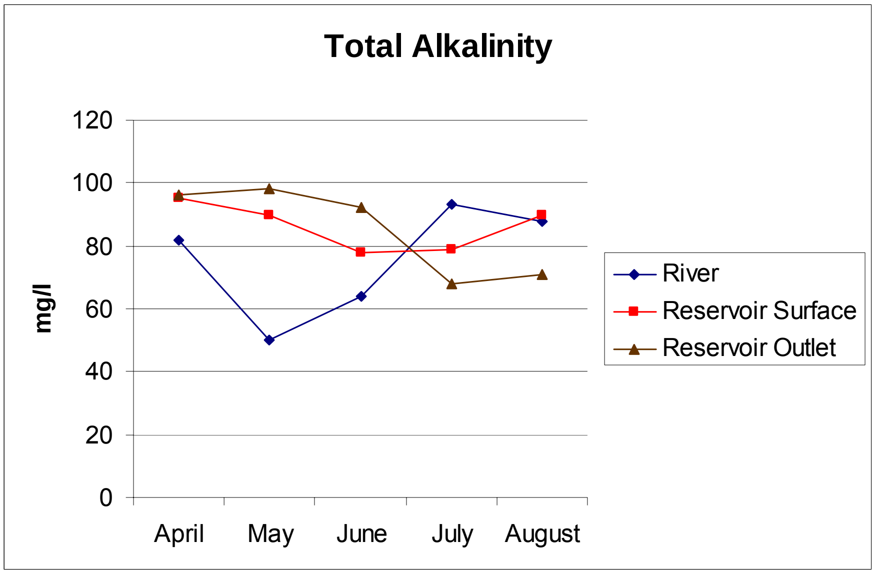
Organic contaminants in surface water are associated with trophic state of the water. Oligotrophic waters are high quality waters associated with low organic content and are most commonly characterized as “pure”. Eutrophic waters are highly organic and contain very high levels of organic matter and are most commonly associated with “swamp” water. Mesotrophic waters are those not characterized as either oligotrophic or eutrophic.

Organic matter in raw water has two deleterious effects on water treatment. When subject to chlorination organic materials create what are know as “disinfection by-products”, or DBPs. DBPs are considered cancer producing compounds. Therefore, highly organic raw waters are considered to posses DBP precursors.

Waters with Total Organic Carbon (TOC) greater than 2.0-mg/l are required to remove some of the organic material in a varying relationship between the TOC level and Alkalinity.

3.1.8.1 Alkalinity

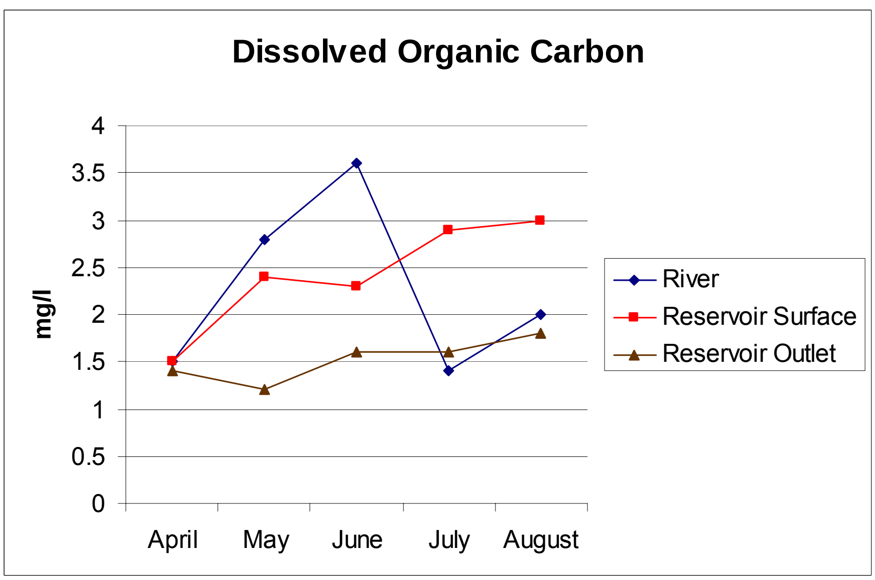
Alkalinity is a measure of a waters resistance to pH change. There is no specific MCL or stream standard for alkalinity. Waters with alkalinity less than 60-mg/l are considered low alkalinity waters.



The River sample during the peak of the Spring runoff exhibited a low alkalinity since snowmelt generally contains little natural alkalinity. The Reservoir Surface and Reservoir Outlet samples all exhibited moderate alkalinity.

3.1.8.2 Dissolved Organic Carbon

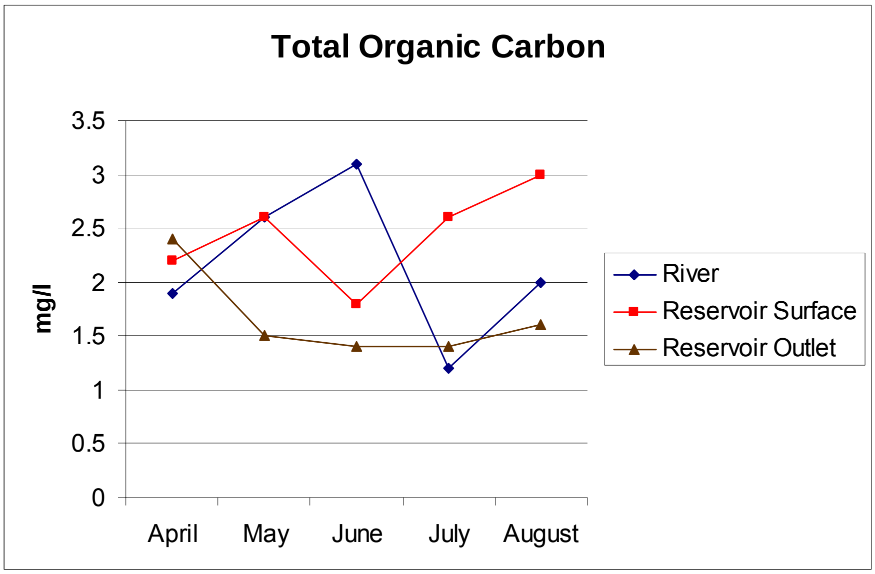
Dissolved Organic Carbon (DOC) is that fraction of the total organic carbon that passes a 0.45 micron filter. While there are no specific MCLs or stream standards for DOC, values below 2.0-mg/l are considered low organic waters.



The River and Reservoir Surface samples generally exceed 2.0-mg/l. Therefore, some organic carbon removal would be required as part of a water treatment system for these waters. The Reservoir Surface sample showed increasing concentration as the summer progressed probably indicating algal growth. All samples from the Reservoir Outlet were considered low organic waters.

3.1.8.3 Total Organic Carbon

Total Organic Carbon (TOC) is a measure of the naturally occurring and manmade organic content of water. Like DOC there are no specific MCLs or stream standards for TOC, values below 2.0-mg/l are considered low organic waters.

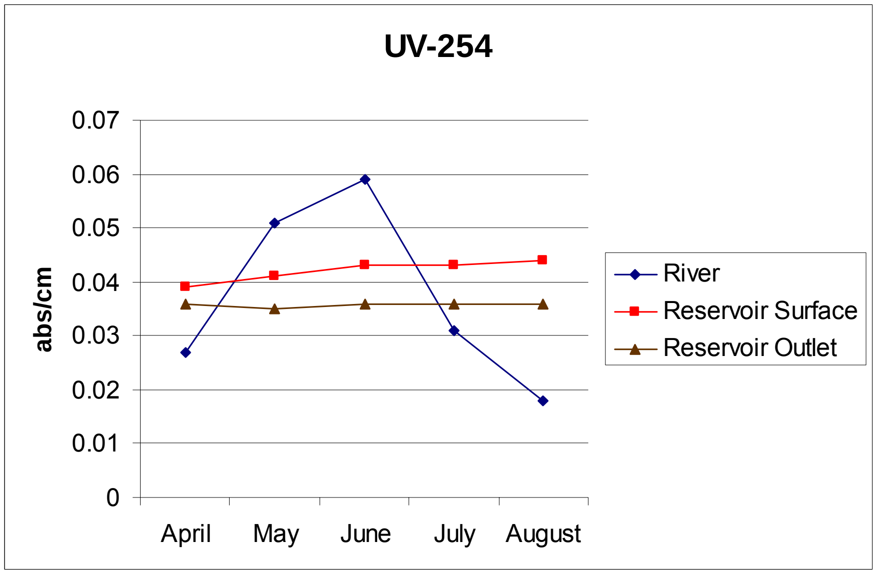


The River sample exceeded 2.0-mg/l TOC in over half of the samples. The Reservoir Surface sample exceeded 2.0-mg/l TOC in four of five samples. The Reservoir Outlet sample had the best quality, exceeding the 2.0-mg/l value in only one sample.

3.1.8.4 UV-254

The Ultraviolet light absorbency at a wavelength of 254 nanometers is another characteristic of the organic content of water. Organic materials, particularly humic substances, absorb UV light at this frequency.

There are no specific MCLs or stream standards associated with UV-254 values.

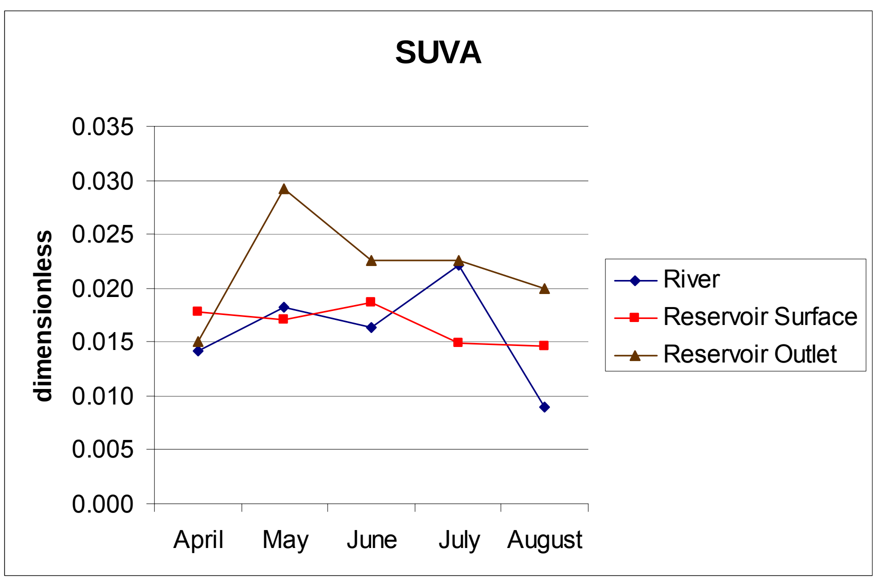


All measured values are low, indicating a low likelihood of humic organic material.

3.1.8.5 SUVA

Specific Ultraviolet Absorbency is an empirical relationship of UV-254 to DOC. It is a measure of the hydrophobic nature of the organic material present. Hydrophobic organic material is more difficult to remove, and causes premature membrane fouling.

There is no specific MCL or stream standard associated with SUVA values. However, SUVA values greater than 4.0 are considered problematic for membrane treatment.



All measured SUVA values are an order of magnitude less than 4.0. Therefore, the water should be easily treated by membrane treatment without fear of organic fouling.

3.1.9 Summary of Water Quality

The water quality of all sites is acceptable for a raw water supply. As expected, the River location is subject to significant fluctuations in quality. The River source would probably favor conventional treatment based on the higher TSS values and need to remove some iron and organic matter.

Both Reservoir samples are very high quality raw water sources. The Reservoir Outlet samples were generally of better quality than the Reservoir Surface samples. Because of the very low TSS values in both Reservoir locations, the water favors membrane treatment over conventional treatment. Based on the TOC and alkalinity values, the treatment system would need to remove 25% of the TOC. This should not be a problem through normal membrane treatment.

[End of Section 3 Text]
[Figure 3-1 Follows]