Descriptions of Common Ground Water Constituents

Constituents and Sources	Significance
Alkalinity is a measure of the capacity of water to neutralize acid. It is expressed in terms of an equivalent concentration of calcium carbonate (milligrams per liter of calcium carbonate) and is caused by the presence of bicarbonate and carbonate ions.	No drinking water standards have been established. High alkalinity (see bicarbonate) may cause an unpleasant taste. It is also detrimental to several industrial processes and may affect irrigated crops.
Aluminum (Al), commonly found in minerals, rocks, and clay, is the most abundant metal in the earth's crust. It usually occurs at low levels in most waters.	Aluminum has a secondary standard range of 50-200 µg/l; levels above this range pose water discoloration problems. Excessive concentrations may cause gastrointestinal irritation. [**7, 10, 11**]
Antimony (Sb) is relatively rare in crustal rocks, occurring most abundantly around geothermal geysers and in some ore deposits. Concentrations in water rarely exceed 3 µg/l.	Antimony has a primary standard of 6 µg/l. It is not considered to be carcinogenic, but high levels can be toxic to the gastrointestinal tract, heart, respiratory tract, skin, and liver. [**7, 10, 11**]
Arsenic (As) occurs naturally in small amounts in sulfide ore deposits. Arsenic has been a component of pesticides and may enter streams or groundwater through pesticide application, waste disposal, or agriculture drainage.	Arsenic has a primary standard of 10 µg/l. Small amounts of arsenic are poisonous and can cause numerous health problems and even death. Arsenic can be present in several ionic forms which vary in toxicity and method of removal. Removal: As +3 and As +6 [**7, 11**]; As +5 [**1, 2, 3, 7, 10, 11**]
Barium (Ba) occurs in igneous and sandstone rocks, and in calcite veins in some limestones. Barium is also widely distributed in soil in the Western and Midwestern U.S. Barium is a component of drilling muds. High concentrations may occur in certain oilfields and some brines.	Barium has a primary standard of 2,000 µg/l (2 mg/l). It is not carcinogenic, but ingesting high levels of barium can cause organ damage and circulatory problems. [**7, 10, 11**]
Beryllium (Be) is a relatively rare element in crustal rocks. Concentrations in groundwater are usually low because of the element's scarcity, low solubility, and adsorption by clays.	Beryllium has a primary standard of 4 µg/l. Long term exposure to high levels of beryllium can possibly cause cancer and/or bone damage. [**7, 10, 11**]
Bicarbonate (HCO_3) and Carbonate (CO_3) Anions are formed by the reaction of carbon dioxide with water and carbonate rocks such as limestone and dolomite.	No drinking water standards have been established. Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers to form scale and release corrosive carbon dioxide gas. [**12**]

****Method of Removal: 1. activated alumina, 2. activated carbon, 3. adsorption, 4. anion exchange, 5. cation exchange, 6. chlorination-precipitation, 7. distillation, 8. electrodialysis, 9. filtration, 10. ion exchange, 11. reverse osmosis, 12. water softener.**

Descriptions of Common Ground Water Constituents

Constituents and Sources	Significance
Boron (B) is relatively rare in crustal rocks found in association with certain volcanic springs and evaporites. The most important boron compound is borax.	No drinking water standard has been established. Boron is necessary for good plant growth; however, excessive boron will render water unsuitable for irrigation. Concentration as high as 1.0 mg/l is permissible for boron-sensitive crops, 2.0 mg/l for semi-sensitive crops, and as much as 3.0 mg/l for boron tolerant crops. [**7, 10, 11**]
Bromide (Br) in natural waters is always present as the bromide anion. Bromide is extracted commercially from seawater and from brines. Its main sources are from sodium, potassium, and magnesium bromide salts found in sedimentary rocks as evaporites, carbonates, and shales. In coastal areas, higher bromide concentrations in the groundwater can be attributed to the infiltration of seawater.	No drinking water standard has been established. The presence of small amounts of bromide in fresh water is not known to have ecological significance. The introduction of bromide into the environment by human activities such as the application of pesticides in urban areas is probably significant. [**7, 10, 11**]
Cadmium (Cd) occurs naturally in zinc ore deposits. Cadmium is used for electroplating and for pigments in paint. It is also used as a stabilizer for PVC plastic and in batteries and fluorescent and video tubes. It can enter the groundwater from industrial and mining operations and from landfills.	Cadmium has a primary standard of 5 µg/l. It accumulates in the kidneys and liver and can result in kidney damage, renal dysfunction, hypertension, and anemia. [**7, 10, 11**]
Calcium (Ca) is dissolved from almost all soils and rocks–especially from limestone, dolomite, and gypsum.	Calcium generally does not pose any health problems. At high levels (in combination with magnesium), it can cause incrustations on utensils and scale deposits in water heaters and boiler tubing. It also reduces soap lather. [**7, 10, 11, 12**]
Chloride (Cl) is a relatively abundant element. It is dissolved mainly from the mineral halite (NaCl) found in sedimentary rocks and soils. Chloride is also present in sewage, oil-field brines, industrial effluent, and seawater.	Chloride has a secondary standard of 300 mg/l. Chloride, when present at levels in excess of 100 mg/l and in combination with sodium, gives drinking water a salty taste and may increase the corrosiveness of the water. [**7, 10, 11**]
Chromium (Cr) is a naturally occurring metallic element occurring most frequently in igneous rocks.	Chromium has a primary standard of 100 µg/l. Trivalent chromium (Cr+3) is an essential element for maintaining good health; a deficiency may result in atherosclerosis. Hexavalent chromium (Cr+6) is very toxic and can damage the liver, skin, kidneys, respiratory and digestive organs, and cause cancer. [**2, 7, 10, 11**]

****Method of Removal: 1. activated alumina, 2. activated carbon, 3. adsorption, 4. anion exchange, 5. cation exchange, 6. chlorination-precipitation, 7. distillation, 8. electrodialysis, 9. filtration, 10. ion exchange, 11. reverse osmosis, 12. water softener.**

Descriptions of Common Ground Water Constituents

Constituents and Sources	Significance
Copper (Cu) is a moderately abundant metallic element that occurs as a free native metal and in copper minerals. Copper may be dissolved from copper pipes and plumbing fixtures, especially if the pH of the water is below 7. Natural waters (free from contamination) usually contain less than 10 µg/l.	Copper has a secondary standard of 1,000 µg/l and an action level of 1,300 µg/l. An action level, if exceeded, triggers treatment or other requirements that a public water system must follow. Copper is an essential element for maintaining good health. A deficiency may result in anemia, loss of pigment, and reduced growth. [**7, 10, 11**]
Fluoride (F) is dissolved in small quantities from minerals most commonly found in carbonate, volcanic, and/or sedimentary rocks. Fluoride is added to many public drinking waters by fluoridation.	Fluoride has a primary standard of 4 mg/l and a secondary standard of 2 mg/l. It is an essential constituent for maintaining good health. Fluoride concentrations between 0.6 and 1.7 mg/l in drinking water have a beneficial effect on the structure and resistance to decay of children's teeth, but excess levels may cause mottling of teeth. [**7, 10, 11**]
Gross Alpha radiation is the emission of positively charged particles from the disintegration (radioactive decay) of certain elements such as uranium, thorium, and radium, among others. Alpha radiation in drinking water can be in the form of dissolved minerals, or in the case of radon, as a gas.	Gross Alpha has a primary standard of 15 pCi/l. Alpha particle radiation cannot penetrate a piece of paper or human skin, but is very dangerous when the radioactive substance is ingested or inhaled. The amount of potential damage to organ tissues depends upon how long the tissues were exposed and the dosage of radiation. [**7, 10, 11**]
Hardness (as $CaCO_3$) is the measure or concentration of calcium, magnesium, and strontium cations expressed in terms of mg/l of calcium carbonate ($CaCO_3$).	Hardness has no standard, but as a general measure is expressed in mg/l of $CaCO_3$: 0 – 60 soft; 61 – 120 moderately hard; 121 – 180 hard; >180 very hard. Hard water forms scale in boilers, water heaters, and pipes; consumes soap lather and deposits soap curd on bathtubs. [**8, 10, 11, 12**]
Iron (Fe) is the second most abundant metallic element in crustal rocks. Concentrations of iron in most natural waters are small–at less than 0.3 mg/l. High levels of iron are present in certain geologic formations. High levels of iron can also be traced to well casings, pipes, pumps, storage tanks, and other cast iron equipment.	Iron has a secondary standard of 300 µg/l. It is an essential element for maintaining good health. An iron deficiency may cause anemia. High levels can stain laundry and utensils cause an unpleasant taste, and favor the growth of iron bacteria. [**6, 7, 9, 10, 11**]

****Method of Removal: 1. activated alumina, 2. activated carbon, 3. adsorption, 4. anion exchange, 5. cation exchange, 6. chlorination-precipitation, 7. distillation, 8. electrodialysis, 9. filtration, 10. ion exchange, 11. reverse osmosis, 12. water softener.**

Descriptions of Common Ground Water Constituents

Constituents and Sources	Significance
Lead (Pb) is a rare metallic element that is widely dispersed in igneous and sedimentary rocks such as shales and carbonates. When elevated levels are detected, the cause is typically lead plumbing and rarely industrial wastes.	Lead has an action level of 15 µg/l. An action level, if exceeded, triggers treatment or other requirements that a public water system must follow. Excess concentrations of lead are known to cause irreversible brain damage when blood levels exceed 1000 – 2000 µg/l. [**7, 11**]
Lithium (Li) is a rare element and is not abundant in nature. Lithium-bearing minerals occur in pegmatites (very coarse-grained intrusive igneous rocks). Elevated levels may occur in brines and thermal springs.	Lithium has no established standard. Some studies have found lithium to be beneficial in the treatment of manic depression and other mental illnesses.
Magnesium (Mg) is common element. Magnesium is a major constituent of the dark-colored minerals associated with igneous rocks. Sedimentary sources of magnesium include carbonates and dolomites.	Magnesium has no established standard. It is an element that is essential to plant and animal nutrition. Elevated levels (in combination with calcium) can cause incrustations on utensils and water heaters and consume soap lather. (See Hardness). [**8, 10, 11, 12**]
Manganese (Mn) is an abundant metallic element in crustal rocks. Many igneous rocks contain manganese. It also is present in small amounts in sedimentary rocks such as dolomites and limestones. Concentrations in groundwater are usually low with elevated levels occurring in brines and thermal springs.	Manganese has a secondary standard of 50 µg/l. It is an essential element for maintaining good health. High levels can stain laundry and plumping and cause taste problems. [**6, 7, 10, 11**]
Mercury (Hg), rare in crustal rocks, occurs as a metallic element and in mercury ore (cinnabar). Concentrations in natural waters are usually less than 2 µg/l, with exceptions occurring near cinnabar mines and some industrial sites.	Mercury has a primary standard of 2 µg/l. Toxicity may cause kidney disease and central nervous system problems. [**7, 11**]
Molybdenum (Mo) is a rare element most commonly found in the minerals molybdenite and wulfenite. Most natural waters contain less than 1 µg/l. Elevated concentrations have been associated with molybdenum mining operations.	Molybdenum has no established standard and is an essential element for maintaining good health. However, excessive concentrations may result in liver, kidney, spleen, and adrenal damage. [**7, 10, 11**]

****Method of Removal: 1. activated alumina, 2. activated carbon, 3. adsorption, 4. anion exchange, 5. cation exchange, 6. chlorination-precipitation, 7. distillation, 8. electrodialysis, 9. filtration, 10. ion exchange, 11. reverse osmosis, 12. water softener.**

Descriptions of Common Ground Water Constituents

Constituents and Sources	Significance
Nitrate (NO_3) plus Nitrite (NO_2). Natural sources of nitrate include mineral deposits, soils, and the atmosphere. Elevated levels can be attributed to decaying organic matter; but also human and animal wastes, industrial discharges, and fertilizers. Higher levels are often found in shallow aquifers easily polluted by sewage and fertilizer application. Nitrite is closely associated with nitrate because it quickly oxidizes to nitrate. Detectable levels of nitrite in water indicate bacterial contamination.	Nitrate as (NO_3) has a primary standard of 44.3 mg/l, but is often reported as nitrite plus nitrate (as nitrogen), which has a primary standard of 10 mg/l. Water with excessively high levels of nitrate have been reported to cause methemoglobinemia (blue-baby syndrome) in infants and should not be used in feeding. It also can encourage the growth of algae and other organisms that give water a bad taste and odor. [**7, 10, 11]**
pH is the concentration of hydrogen ions and represents the acidic qualities of the water. Acids and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates raise the pH.	pH has a secondary standard range of 6.5 – 8.5. A pH of 7 is neutral; a pH less than 7 is acidic; and a pH greater than 7 is alkaline. Both low and high pH levels are corrosive and may degrade metals. A pH of 7 or greater can cause scaling problems in pipes.
Potassium (K) is common in silicate minerals such as feldspars and in clays minerals like illite.	Potassium has no established standard, and its effect on drinking water is limited. [**7, 10, 11**]
Radium 226 + 228 are the dominant radioactive isotopes detected in natural waters. Radium-226 (an alpha particle emitter) is a disintegration product of uranium-238, and radium-228 (a beta particle emitter) is a disintegration product of thorium-232.	Radium 226 plus 228 has a primary standard of 5 pCi/L. Radium is deposited in the bones. Excessive levels of radium in water may cause bone and bone marrow cancers in humans. [**10,11**]
Sodium Adsorption Rate (SAR) is an indicator of the sodium hazard of irrigation water.	SAR is the proportion of sodium (Na) compared to the concentration of calcium (Ca) plus magnesium (Mg). The SAR value should not be higher than 20 and preferably less than 10. SAR: 1-10 low sodium hazard; SAR: 10-18 medium sodium hazard; SAR : 18-26 high sodium hazard; SAR: >26 very high sodium hazard.

****Method of Removal: 1. activated alumina, 2. activated carbon, 3. adsorption, 4. anion exchange, 5. cation exchange, 6. chlorination-precipitation, 7. distillation, 8. electrodialysis, 9. filtration, 10. ion exchange, 11. reverse osmosis, 12. water softener.**

Descriptions of Common Ground Water Constituents

Constituents and Sources	Significance
Selenium (Se) is a rare non-metallic element that is widely distributed in sediments in very small amounts. Concentration in groundwater rarely exceed 1 µg/l.	Selenium has a primary standard of 50 µg/l. It is an essential element for maintaining good health. A deficiency may result in myopathies (muscle diseases) and possible liver damage. An excessive amount may produce inhibited growth and skin dermatitis. [**1, 7, 10, 11**]
Silica (SiO_2) is an abundant mineral in the earth's crust. The main sources of silica are from silicate rocks composted of quartz, chert, feldspars, and clay minerals. Silicates make up 95% of crustal rock.	Silica has no established standard. Silica, combined with calcium and magnesium, forms scale in pipes, boilers, and steam turbines. [**7, 10, 11**]
Silver (Ag) is a rare metallic element found mostly in igneous rocks. It is used in the production of photographic film and other industries.	Silver has a secondary standard of 100 µg/l. [**7, 10, 11**]
Sodium (Na) is dissolved from minerals and rocks such as feldspars, clay, halite, and other evaporites.	Sodium has no established standard and is an essential element for maintaining good health. Sodium, occurring at levels greater than 200 mg/l in combination with chloride, gives water a salty taste. [**7, 10, 11**]
Strontium (Sr) is found in igneous rocks and sedimentary rocks such as shales and carbonates. Strontium-90 is a radioactive isotope found in fallout from certain nuclear explosions.	Strontium has no established standard. Strontium, in combination with other minerals, affects the hardness of water. (See Hardness) [**7, 10**]
Sulfate (SO_4) occurs naturally and is dissolved from rocks and soils containing gypsum, iron, sulfides, and other sulfur compounds. Sulfates are also present in some mining and industrial wastes.	Sulfate has a secondary standard of 300 mg/l. High levels can give water a bitter taste, rotten-egg smell, and cause diarrhea. In combination with calcium, sulfate forms scale in pipes and boilers. [**10**]
Thallium (Tl) occurs naturally, usually as sulfides. It is used in making electronic devices, alloys, and glass. Levels in groundwater are normally low, but can be elevated by pollution from coal-burning, metal-smelting, or ore processing.	Thallium has a primary standard of 2 µg/l. High concentrations can affect the nervous system, lungs, heart, and kidney, and cause vomiting, diarrhea, and possibly death, depending on the amount ingested. [**7, 10, 11**]

****Method of Removal: 1. activated alumina, 2. activated carbon, 3. adsorption, 4. anion exchange, 5. cation exchange, 6. chlorination-precipitation, 7. distillation, 8. electrodialysis, 9. filtration, 10. ion exchange, 11. reverse osmosis, 12. water softener.**

Descriptions of Common Ground Water Constituents

Constituents and Sources	Significance
Total Dissolved Solids (TDS) and Conductivity. Total dissolved solids are the approximate total amount of mineral constituents (primarily Ca, Cl, K, Mg, Na, NO_3, bicarbonate, and carbonate ions) dissolved from rocks and soils in water. Conductivity is an indicator of the salinity or mineral content of water and can be used to estimate total dissolved solids.	Total Dissolved Solids (TDS) and conductivity are general indicators of water quality. TDS has a secondary standard of 1,000 mg/l whereas conductivity has none. TDS: 1,000 mg/l or less fresh water; TDS: 1,001 – 3,000 mg/l slightly saline; TDS: 3,001 – 10,000 mg/l moderately saline; TDS: 10,001 – 35,000 mg/l very saline; TDS: 35,000 mg/l or greater are brines.
Uranium (U) is a naturally occurring radioactive, metallic element commonly found in very small amounts in rocks, soil, water, and plants. A common source is the erosion of natural deposits of uranium. It can also be removed and concentrated through mining activities.	Uranium has a primary standard of 30 µg/l. It can cause certain cancers. If ingested, uranium, like radium, may accumulate in bones and cause mutations. [**4, 5, 7, 8, 11**]
Vanadium (V) is a relatively rare element found in certain lead and uranium ore deposits. Natural waters rarely have levels exceeding 10 µg/l.	Vanadium has no established standard. Although deficiency results are unknown, vanadium is considered toxic; inhalation exposures may damage the respiratory system. [**7, 10, 11**]
Zinc (Z) is an abundant metallic element in metallic ore deposits. It is used in the manufacture of steel and in the production of paints, rubber, cosmetics, and plastics.	Zinc has a secondary standard of 5,000 µg/l. It is an essential element for maintaining good health. Excessive concentrations may result in irritability, muscle stiffness and pain, loss of appetite, and nausea. [**7, 10, 11**]

****Method of Removal: 1. activated alumina, 2. activated carbon, 3. adsorption, 4. anion exchange, 5. cation exchange, 6. chlorination-precipitation, 7. distillation, 8. electrodialysis, 9. filtration, 10. ion exchange, 11. reverse osmosis, 12. water softener.**