# QUALITY OF GROUND WATER--CHANGES AND PROBLEMS

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Changes and problems associated with quality of ground water, as presented in this paper, are separated into three categories: (1) general characteristics of water; (2) changes in quality of ground water; and (3) quality-of-water problems associated with ground water.

Information on the quality of ground waters is obtained by representative sampling of various aquifers in areal or hydrologic studies of the water resources. Standard analytical methods are used to determine the chemical composition of these representative water samples. Chemical analytical results are used as an aid in determining the source of under-ground and surface waters and in defining the subsurface geology of an area.

For many years the U. S. Geological Survey and the State of New Mexico have cooperated in the study of ground-water quality in New Mexico. This paper presents general information on the quality of ground water that has been learned from these investigations and from reports of the Geological Survey and other Federal agencies.

All water is wet and, except for water containing suspended matter or organic material, it all looks about the same. Frequently, the similarity ends at this point. Distilled water and sea water may be cited as examples of the above criteria.

Water often is called the universal solvent because most substances are soluble in it, at least to a small degree. As water moves through the hydrologic cycle from rain, to surface runoff, to infiltration into the ground-water table, it dissolves gases of the atmosphere and soil and earth minerals and picks up suspended material. Even rainfall contains a certain amount of these materials. Surface runoff normally contains small to moderate amounts of dissolved solids and after heavy rains may contain a large amount of suspended matter. As the water percolates into the ground-water table, generally all of the suspended matter is removed; hence, the suspended sediment loads of natural recharge water are usually of no consequence in ground-water investigations.

The type of dissoved minerals in natural water depends primarily on the type of rocks or soils with which the water has been in contact and the length of time of contact. Ground water generally is more saline than surface runoff because it remains in contact with rocks and soils for much longer periods.

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Composition of ground water

The principal constituents of ground water are the bicarbonates, sulfates, and chlorides of the alkaline earth and the alkali metals. Other constituents often present in ground water, but usually in lesser amounts, are silica, iron, manganese, heavy metals, fluoride, nitrate, phosphate, boron, hydrogen sulfide, and carbon dioxide.

The source and the significance of some of the dissolved constituents of natural water are discussed in the following paragraphs.

Silica is dissolved from practically all rocks and usually is nonionized. Because quartz is so resistant to solution by water, most silica in water probably is derived from the decomposition or metamorphism of silicate minerals rather than from solution of quartz. Water from many sources contains less than 10 ppm (parts per million) of silica. However, water that contacts deposits high in silicate minerals, particularly the feldspars, may contain as much as 60 ppm silica. Concentrations exceeding 100 ppm of silica are rarely found in natural water (Rainwater and Thatcher, 1960, p. 259).

Iron, one of the most abundant minerals in the earth's crust, occurs in the dark-colored silicate minerals of igneous rocks, and as sulfides and oxides. Iron oxide and iron hydroxide are often present as cementing materials in sandstone. Although iron is fairly soluble, it is usually found only in small concentrations in water because it is readily precipitated as a hydroxide (Rainwater and Thatcher, 1960, p. 183). For most uses, concentrations exceeding 0.3 to 0.5 ppm are objectionable.

Calcium occurs in most rocks and soils. The highest concentrations usually found in water that has been in contact with limestone, dolomite, or gypsum. Water that has been in contact with granite generally contains less than 10 ppm of calcium, whereas water that has been in contact with dolomite or limestone may contain from 30 to 100 ppm of calcium (Rainwater and Thatcher, 1960, p. 127). Gypsum, which is abundant in New Mexico, is the greatest contributor of calcium to water. Water that has been in contact with gypsum may contain several hundred ppm of calcium.

Magnesium is dissolved primarily from dolomitic rocks. Soft water usually will contain only 1 or 2 ppm of magnesium, but water that has been in contact with dolomite may contain as much as 20 to 100 ppm (U.S. Geol. Survey WSP 1522, 1961, p. 10).

Sodium and potassium have similar characteristics and usually are found together in most soils and rocks; however, sodium is more abundant in nature than potassium. Sodium usually is the predominant cation in the highly mineralized water in the western United States. When the concentration of sodium and potassium are both low, they may be of about equal proportions; in high concentrations, sodium usually predominates. Sodium remains in solution rather persistently when it is leached from rocks, whereas potassium is easily recombined with other products of weathering such as the clay minerals (Hem, 1959, p. 89). Frequently the concentration of sodium and potassium is computed rather than determined by specific analysis and is reported as the equivalent amount of sodium. The use of sodium salts is common in industry, and many industrial wastes may contain large quantities of sodium that may find its way into streams or ground-water aquifers.

Bicarbonate and carbonate are common in ground water because of the abundance of carbonate minerals in nature and because carbon dioxide, that helps dissolve them, is readily available (Rainwater and Thatcher, 1960, p. 93). Bicarbonate concentrations range from less than 50 ppm in water from relatively insoluble rocks to as much as 400 ppm in water from limestone (U.S. Geol. Survey WSP 1522, 1961, p. 11).

Sulfate occurs in most sedimentary rocks and soils. It is especially abundant in gypsum and in some beds of shale. Water from mines may be high in sulfate as a result of the oxidation of pyrite. Organic material containing sulfur may also add to the sulfate content of water. Sulfate is discharged by many industrial plants as a waste product (Rainwater and Thatcher, 1960, p. 279). As a result, sulfate concentrations in both surface and ground waters may range from a few parts per million to several thousand parts per million.

Chloride is the major anion in many natural water supplies and in most brines. Chloride concentrations in natural water may range from less than 1 ppm in fresh water to several thousand parts per million in brines (Rainwater and Thatcher, 1960, p. 141). Irrigation return flows and industrial wastes may greatly increase the chloride content above that generally found in natural water.

Fluoride is only sparingly soluble and is present in most natural waters in only small amounts. Calcium fluoride is its principal source. The element is often characteristic of water from deep strata and is frequently found in salt water from oil wells (Rainwater and Thatcher, 1960, p. 163).

Nitrate is another anion found in a wide range of concentrations in ground water. Normally, concentrations of nitrate are low in natural water, and high concentrations of nitrate generally indicate contamination by sewage or organic material. If contamination of an aquifer by sewage or industrial waste is suspected, the nitrate concentration should be determined and checked against previous determinations if they are available. Hem (1959, p. 118) reports that contaminated water in Carlsbad Caverns had a nitrate content of about 850 ppm.

Boron is present as an anion or in nonionic form in natural water. Boron concentrations are generally quite small in comparison to other consituents, and a concentration of 5 ppm is considered very high. The element is essential to plant growth but is toxic to most plants at concentrations of more than 2 or 3 ppm. The higher concentrations of boron are usually found in water that has been in contact with igneous rocks (Rainwater and Thatcher, 1960, p. 113).

Many other constituents occur in natural water in very small, or minute quantities. The more common of these are aluminum, manganese, chromium, nickel, copper, lead, zinc, cobalt, arsenic, selenium, cadmium, strontium, phosphate, and barium. Thus, high concentrations of any of these constituents generally indicate contamination from sources such as industrial or sewage effluent, insecticides, pesticides, or herbicides. Some of these minor constituents--such as lead, arsenic, and selenium--are toxic to human beings or animals if present in high concentrations. The U. S. Public Health Service (1961, p. 11) drinking water standards states that the presence of lead or arsenic in excess of 0.05 ppm or of selenium in excess of 0.01 ppm constitute grounds for rejection of the supply.

Physical properties of natural water

Various physical properties affect the quality of water. Color, taste, odor, temperature, sediment content, and specific conductance must be given consideration when water is to be used for domestic, municipal, or industrial purposes. Color in water usually is caused by organic matter that is extracted from leaves, roots, or other organic substances in the ground. A high concentration of one or more of the inorganic constituents previously discussed often causes an objectionable taste in water. Odor may be caused by gases released from decomposition of organic matter or sewage effluent. Except for thermal springs, groundwater temperatures usually are quite uniform for a given depth below the land surface. However, these temperatures may be altered by industrial use. Ground water that is used for cooling and then is returned to the aquifer will cause a temperature change in the aquifer.

Specific conductance of water is a measure of its capacity to conduct a current of electricity. It varies with the concentration and degree of ionization of the different minerals in solution and with the temperature of the water. Specific conductance is useful in evaluating chemical quality of water. It may be used for estimating the dissolved solids in solution, as the dissolved solids in parts per million usually will equal about 65 percent of the conductance value expressed in micromhos per centimeter at 25°C. Relatively easy to determine, either in the field or in the laboratory, it is a very popular determination for estimating quality of water.

## Expression of Water Analyses

The quantities of dissolved materials found in water usually are expressed in parts per million. A part per million is a unit weight of a constituent, or constituents, in a million unit weights of solution.

Chemical analyses frequently are expressed in equivalents per million. An equivalent per million is a unit chemical combining weight of a constituent in a million unit weights of solution. Water is electrically neutral. Thus for the dissolved constituents, the sum of the charges on the cations, positively charged ions, must equal the sum of the charges on the anions, negatively charged ions. The accuracy and the completeness of a chemical analysis, in which the common anions and cations and silica have been determined, can be checked.

## Factors Affecting Quality of Ground Water

Water is nearly always moving and is constantly undergoing change. Two general types of phenomena--natural and artifical--affect the quality of water. The two most important natural phenomena are the precipitation pattern and the intensity of precipitation. The runoff and the recharge water from precipitation that falls on soluble rocks such as gypsum or dolomite will contain higher concentrations of dissolved solids than water from precipitation falling on relatively insoluble rocks such as igneous rocks. Intensity of precipitation also can have an affect on the quality of ground water. If the precipitation is intense and of short duration, only a small portion of the total rainfall will filter into the ground and little or none will reach the water table, and there will be little affect on the quality of the ground water. On the other hand, if the rainfall is of low intensity and long duration most of it may filter into the ground to dissolve minerals from the material through which it passes. Thus the type of soil or rock that makes up the zone of recharge and the distance between the zone of recharge and the aquifer also have major influence on the quality of the water.

Evapotranspiration is another phenomenon that affects shallow aquifers. Evapotranspiration will increase the dissolved solids in water because the water is removed and the dissolved minerals remain.

Many artificial factors can create changes in the quality of ground water. The drilling of a well and the method of casing it are important factors in the quality of water obtained from the well. Mixing of waters of different quality may take place in a well penetrating more than one aquifer.

Mixing of water from different aquifers is not always bad, but it may create problems if it is not anticipated and understood. Pumping may induce a change in the quality of the ground water even when only a single aquifer is penetrated. Intermittent pumping probably will have little effect on the quality of the water, but continued pumping creates a larger zone of depression and causes water from greater distances or other aquifers to move into the area. If this water has been in contact with other type materials, the quality of the water in a given well may change considerably. Pumping may create changes in the quality of ground water in closed basins. Wells in these areas usually are drilled in a ring around the fringe of the basin. The slope of the ground-water table normally is towards the center of the basin, and an increase in the salinity generally occurs in the same direction. Heavy pumping in the fringe area can create a water table slope in the opposite direction and permit the saline water from the central area to flow into the fresh water. Thus in closed basins water-table levels and slopes should be watched closely when heavy pumping is taking place.

Irrigation often will affect the quality of shallow-water tables in or near the irrigated area. Irrigation has a tendency to increase the dissolved-solids content of the soil water because crops use water almost always in excess of the salt intake and leave the increased concentration of salts in the soil.

These salts may be leached out by excessive use of irrigation water or by rain. The excess salts gradually will filter into the shallow-water table by direct percolation or by flowing into streams and returning to the water table at some downstream point.

Industrial and municipal wastes are sources of artifical change in the quality of ground water. When waste effluents are discharged into a stream the water may get into a ground-water table at some downstream point. A relatively new factor in this type of waste is detergent material. Synthetic detergents are materials that have the cleansing action of soap but are not derived directly from fats and oils. They are not readily removed from sewage by normal treatment. In many rapidly growing areas such as near Albuquerque and other large cities in the state, sewage is kept in cess pools or septic tanks. When this situation exists, detergents may find their way directly into the ground water.

Artifical recharge may affect the quality of ground water. Artifical recharge has not been used extensively before the present time, but considerable study has been made of it as a means of storing water for future use. Generally, the chemical quality of the water changes if water from the surface is injected directly into a ground-water aquifer. This change may range anywhere from a slight concentration of dissolved solids to a change that causes precipitates to form in the aquifer. Suspended sediment is another factor that may change the quality of ground water if it is injected with the artifical recharge water. As most surface water contains suspended sediment, this material should be removed before the water is injected into the aquifer; otherwise, the pores in the aquifer may become clogged. Also, an exchange between ions of sediment and ions in solution may take place and create a change in the quality of the water.

## Quality-of-Water Problems Associated with Ground Water, General

Dissolved minerals usually limit the suitability of water for certain uses. Quality-of-water problems usually are intensified in ground water because ground water frequently is more saline than surface water. Quality-of-water problems and water utilization are intricately related. Some constituent that may create a problem for one type of use may actually be an asset for another use. For example, nitrate is objectionable in concentrations of as much as 45 ppm in domestic or municipal water supplies, but it usually is an asset for irrigation purposes.

The most common quality-of-water problems associated with ground water will be discussed as various problem types. All of us, regardless of our profession or professional connection with water problems, are concerned primarily with domestic and municipal supplies, because each and every one of us has a personal interest in how these supplies may affect our day-to-day activities. Therefore, let us consider the effect that some of these major constituents have on our domestic and municipal water supplies. Silica is not physiologically significant to humans or livestock, (Rainwater and Thatcher, 1960, p. 259) but it creates a quality-of-water problem because it contributes to the formation of scale in plumbing fixtures. Calcium and magnesium cause hardness in water. The higher the concentration of these constituents, the greater the hardness and the more soap that will be required for laundering. Tolerance for hardness is a relative factor. Water that might be considered soft in New Mexico or in the Southwest probably would be considered hard in the eastern part of the United States. However, regardless of the locality, water containing more than approximately 200 to 300 ppm hardness would be considered hard. The national average hardness for domestic water supplies is about 100 ppm (Lohr and Love, 1954, p. 19). It might be of interest to compare the hardness of the municipal supplies of the major cities in New Mexico to the national average. The U. S. Geological Survey Water-Supply Papers 1299 and 1300 entitled "The Industrial Utility of Public Water Supplies in the United States, 1952" present representative chemical analyses and miscellaneous information such as ownership, source, treatment and storage facilities concerning the water supplies of the major cities of the United States.

Water-Supply Paper 1299 is for the states east of the Mississippi River, and 1300 is for the states west of the Mississippi River. Water-Supply Paper 1300 lists 13 cities in New Mexico which were major cities on the basis of the 1950 population. Of these 13 cities, 10 obtained their water from ground-water sources, two from surface-water sources, and one from a mixture of surface and ground-water sources. Hardness of water of the two cities using surface-water sources was less than the national average of 100 ppm. One city obtaining its water from a ground-water source was at the national average of 100 ppm. Four cities using ground water, and one using surface water had water hardness ranging from 100 to 200 ppm hardness. There were two cities using ground water sources with 200 to 300 ppm hardness, two cities using ground water had 300 to 500 ppm hardness, and four New Mexico cities using ground water had hardness concentrations in excess of 500 ppm. No specific cities that fall in the various categories were named; however, the above figures were taken from Water-Supply Paper 1300 (Lohr and Love, 1954, p. 286-296).

Sodium and potassium are not particularly objectionable in municipal or domestic supplies, but they will contribute to the saltiness of the water. Sulfate combined with calcium will tend to form hard scale in pipes. If large amounts of sulfate and either magnesium or sodium are present, the water will have an adverse biological effect upon a person, as the chemical constituents of epsom salts and glauber's salts are magnesium-sulfate and sodium-sulfate respectively. Chloride contributes to the saltiness of the water supply and may cause the water to be corrosive if the water contains large quantities of calcium or magnesium (U. S. Geol. Survey WSP 1522, 1961, p. 11).

Fluoride in water has been a rather controversial issue in some municipalities in recent years. Studies indicate that the incidence of dental decay is less in areas having water supplies containing a small amount of fluoride than when there is none. However, concentrations greater than about 1.5 ppm may cause mottled teeth in children during calcification or formation of the teeth (Dean, 1936, p. 1269-1272). According to the National Research Council, Maxcy (1950, p. 271) concludes that nitrate concentrations in excess of about 44 ppm may contribute to the occurrence of blue babies and should be regarded as unsafe for infant feeding.

The U. S. Public Health Service (1961, p. 11) drinking water standards recommend that dissolved solids should not exceed 500 ppm. According to Water-Supply Paper 1300, three of the 13 cities listed in New Mexico have water supplies with dissolved-solids contents of less than 200 ppm. All three of these supplies are surface water. Six New Mexico cities use ground-water sources in which the dissolved-solids content ranges from 200 to 500 ppm. Five cities in the State use ground-water sources that have water supplies with 500 to 1000 ppm. Three cities use ground-water supplies that contain more than 1000 ppm. Fortunately, these three cities have other sources of water. One has a source in the 200 to 500 ppm range, and the other two have sources in the 500 to 1000 ppm range.

In addition to setting a maximum recommended dissolved-solids content for drinking water, the U. S. Public Health Service states that the following chemical constituents in water supplies should not exceed the concentrations shown in parts per million (U.S. Public Health Service, 1961).

| Substance | Concentration in mg/l |
|---|---|
| Alkyl Benzene Sulfonate (ABS) | 0.5 |
| Arsenic (As) | .01 |
| Chloride (Cl) | 250 |
| Copper (Cu) | 1.0 |
| Carbon Chloroform Extract (CCE) | .2 |
| Cyanide (CN) | .01 |
| Fluoride (F) | 1.5 |
| Iron (Fe) | .3 |
| Manganese (Mn) | .05 |
| Nitrate ($NO_3$) | 45 |
| Phenols | .001 |
| Sulfate ($SO_4$) | 250 |
| Total Dissoved Solids | 500 |
| Zinc (Zn) | 5.0 |

The greatest use of water in New Mexico is for irrigation. The U. S. Department of Agriculture recommends that the conductance of water used for irrigation should not exceed 2,250 micromhos per centimeter unless the water is used abundantly and subsoil drainage is good (U.S. Salinity Laboratory Staff, 1954, p. 70). In New Mexico, ground water containing several thousand parts per million dissolved solids sometimes is used successfully for irrigation where the land is well drained and the soluble salts can be removed through the application of large volumes of water. This practice is used most extensively in the lower Pecos River valley. A saline condition will gradually develop in the soil, and an alkali flat that will not support vegetation will eventually develop if water having a high content is used for irrigation where drainage is not adequate.

High sodium concentrations in irrigation water may create soil problems. In evaluating water to be used for irrigation, sodium is expressed as percent sodium, which is the ratio of sodium to the sum of all cations multiplied by 100 on the basis of concentrations expressed in equivalents per million. A percent sodium inexcess of 60 is generally considered undesirable for irrigation water because it will have a tendency to make the soil impermeable to water.

Another factor of water quality that must be considered in irrigation is residual sodium carbonate. If the irrigation water contains a high concentration of the bicarbonate ion, calcium and magnesium carbonate tend to precipitate out of the solution. If this occurs, the concentrations of calcium and magnesium in the solution are reduced, and the relative proportion of sodium is increased. The bicarbonate that remains in solution after the calcium and magnesium have precipitated will combine with sodium to form residual sodium carbonate. Increasing the percent sodium has the same effect as that previously described for sodium, and the sodium carbonate tends to produce the condition known as black alkali. Irrigation water containing more than about 2.5 epm (equivalents per million) of residual sodium carbonate generally is considered unsuitable for irrigation. However, if the land is well drained and the soil is sandy, it is often possible to irrigate with water containing much more than the recommended 2.5 epm of residual sodium carbonate (U. S. Salinity Laboratory Staff, 1954, p. 81-82).

Sodium chloride, the most common salt in saline water, also influences the suitability of ground water for irrigation use. Very few useful plants can tolerate a high concentration of sodium chloride.

Boron is another constituent in water that may limit the suitability of water for irrigation. Boron in very small quantities is essential to plant growth, but it is very toxic at concentrations only slightly more than the optimum. According to the U. S. Department of Agriculture, boron sensitive crops such as oranges, apples, or navy beans can stand about 1 ppm of boron; and boron tolerant crops such as cabbage, alfalfa and sugar beets can tolerate about 2 or 3 ppm of boron (U. S. Salinity Laboratory Staff, 1954, p. 67, 81).

Quality of water causes various problems for industry. As more and more water in the state is diverted to industrial use, these problems will probably be magnified. Quality-of-water problems associated with industry are usually quite different from those associated with irrigation. For example, quality of the water frequently dictates the type of crop that may be grown with irrigation or the type of soil and drainage that are necessary. On the other hand, industry is usually able to seek out the quality of water that it needs or can alter it to fit its needs because of the smaller amount of water used and the higher unit economic value of the product produced. Industries generally will not locate in municipalities having water of poor quality. In general, each industry has its specific water requirements and is usually prepared to alter the water to fit its particular needs (California State Water Pollution Control Board, 1952, p. 127). Ground water is often used by industry because it is generally of a uniform quality. Ordinarily industry can treat water to fit its needs, but the treatment is simplified if the source is of uniform quality. The treatment processes of surface water used for industry must be changed when there are rapid changes in the quality of surface runoff. Most quality-of-water problems associated with industry are similar to those that were outlined for domestic and municipal use. The factors that cause scale or corrosion in plumbing fixtures will do the same thing in industrial plants. However, the problems may be more serious because of the use of high pressure boilers in many industries.

## Quality-of-Water Problem Areas in New Mexico

Before closing I would like to discuss briefly the quality of water and a few of its allied problems in specific areas in the State of New Mexico. The chemical quality of ground water in New Mexico is variable. Analyses of two water samples collected in two different areas of New Mexico support this statement. For example, water from a spring in the Sangre de Cristo mountains in northern New Mexico has a dissolved-solids content of only 21 ppm. The opposite extreme is represented by a brine sample that has a dissolved-solids content of 275,000 ppm. The source of this sample is a test well in the Malaga Bend area in Eddy County in southeastern New Mexico. The average concentration of sea water is about 35,000 ppm; thus, this brine has roughly eight times the dissolved-solids content of sea water.

There are relatively few quality-of-water problems associated with ground water in the high mountain country of New Mexico. Most of these problems are in the lowlands or river valleys where irrigation is practiced extensively and the ground-water reservoir is often recharged from the streams.

Above Elephant Butte Reservoir, the Rio Grande basin has relatively few quality-of-ground-water problems. However, downstream in the Mesilla Valley, deterioration of quality of ground water is recognized. The deterioration probably is caused by two factors: (1) recharge from the Rio Grande, which has a greater dissolved-solids content downstream than above the Reservoir and (2) extensive pumping that has been done in past years to augment the surface-water supply. Pumping has brought ground-water from greater distances than is ordinary and, as might be expected, dissolved-solids content of the ground water has increased.

Quality-of-water is a much greater problem in the Tularosa "closed basin." Except for a fringe around the edge of the basin, most of the ground water in the Tularosa basin is saline and cannot be utilized. Thus, it is difficult to find potable-water supplies for the expanding population and the military facilities in the basin.

The upper Pecos River valley, as in the upper Rio Grande basin, does not have any particular quality-of-water problem. However, many of the ground-water supplies in the middle Pecos River valley have very high concentrations of calcium and sulfate because of solution of underground gypsum deposits. In general, the water in the middle valley is suitable for irrigation, but in many places it is unsuitable for domestic or municipal supplies. As in the Mesilla Valley, the quality of the ground water has deteriorated because of heavy pumping and the resultant import of water. Another factor that contributes to deterioration of the quality of ground water in shallow aquifers of the middle Pecos valley is phreatophytes, principally salt cedar. Salt cedars have a tendency to increase the concentration of the dissolved solids in the shallow aquifers because they use the water and leave most of the salts behind.

The quality-of-water problems in the lower Pecos River valley are of the same type as those in the middle valley, but they are magnified. Some of the ground water in the lower basin is brine that originates from ground water flowing through and over evaporite deposits. These deposits are predominantly sodium chloride, or common table salt. However, some of the brines are also quite high in calcium, magnesium, and sulfate. Some of the ground water used in the lower Pecos valley for irrigation has considerably higher dissolved-solids content than that recommended by the U. S. Department of Agriculture. Thus, excess water must be used and adequate drainage must be provided to insure continued production.

Quality-of-water problems have an entirely different pattern in the high plains of eastern New Mexico. As there is very little surface recharge to the ground-water table in this area, irrigation practices do not have as great an affect on the quality of the water as they do in some of the river valleys. Probably the greatest quality of water problem in the high plains area is contamination of some aquifers by oil-field brines. Also, in the high plains there are areas where nitrate concentrations exceed 40 ppm and fluoride concentrations range from 5 to 7 ppm.

The San Juan basin also has quality-of-water problems. In general, the shallow water tables along the San Juan river contain good water where they are recharged from the river. However, the ground water in deep aquifers is brackish or saline in many places. Also, in the San Juan basin heavy pumping has had its effect on the quality of the ground water as ground water from other areas has been imported.

High nitrate concentrations occurring in ground-water aquifers, as a result of contamination from effluent of uranium processing plants, has created a quality-of-water problem in some areas of the state. However, this situation is probably under control at the present time because of changes in processing methods.

The quality of ground water problems that I have just discussed in the various areas in the state are general in nature and, in most cases, are the predominant ones. I doubt if there is any quality of water problem that is restricted to any one specific area.

## Conclusion

Many of the quality-of-water problems are natural phenomena, but the majority of them are caused, or are complicated, by man's activities. Any use man makes of water, whether it be domestic, municipal, irrigation, or industrial, will affect the quality of the water. Because of limited water supplies and increased demand for water, research in quality of water and in man's activities with water is needed to determine what can be done to minimize these changes.

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