

## SEDIMENT AND ITS EFFECT ON WATER QUALITY

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### INTRODUCTION

This paper describes the water uses that are affected by sediment, how these uses are affected, the impact of sediment on water quality in New Mexico and the factors which contribute to its presence.

The word "sediment" has several meanings, depending upon its use. To the geologist it is usually considered to be finely divided rock fragments; however, the common visual test for the degree of pollution in terms of turbidity does not distinguish one source of the material from another when it is in suspension. Turbidity is defined as the degree of opaqueness of water due to the amount of fine matter in suspension. Sediment is defined in this paper as inorganic or organic particles originating from weathering, chemical precipitation, or biological activity, and transported, suspended, or deposited by water, air, ice, gravity, or combinations of these agents.

Turbidity tests measure the amount of light penetration in water, usually in terms of Jackson turbidity units. The standard unit of turbidity is that produced by one part per million of silica diatomaceous earth or fullers earth) in distilled water (1). The depth at which a light image from a candle or other artificial source disappears is the calibrated level of turbidity. The turbidity test does not correlate with determination of sediment concentrations. In this determination, the sediment in a representative sample of a water-sediment mixture is dried and weighed. The percentage of this weight to the total sample is reported in parts per million. Reasons for a lack of correspondence include the fact that color can affect the amount of light penetration without the presence of suspended particles and that finer particles intercept light more effectively than coarser particles even though the weight of sediment in two samples is the same.

### WATER QUALITY PARAMETERS AFFECTED BY SEDIMENT

The following is a brief description of standards for good quality water pertaining to sediment content. These standards are based on experience in the use of water affected by sediment.

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### 1. Water Supply, Drinking, Culinary and Food Processing.

Water for these purposes should have a clarity equivalent to less than 5 Jackson turbidity units (2) or no greater than 10 parts per million by weight (3). The small amount of sediment that could be present to keep within this standard would not usually be visible to the eye. Reasons for high standards include the aesthetic value of clear water, greater palatability, and greater ease of ridding water of bacteria when it is nearly free of suspended solids.

### 2. Industrial Water Supply.

The American Water Works Association (4) has recommended desirable upper limits of turbidity in parts per million (silica scale) for the following industrial processes:

Brewing	10 ppm	Soda and sulphite	15 ppm
Carbonated beverages	2 "	Light paper	5 "
Paper and pulp		Tanning	20 "
Groundwood	50 "	Textiles	5 "
Kraft pulp	25 "		

### 3. Bathing, Swimming and Recreation

The two factors which determine limits on the presence of sediment for these purposes are safety and aesthetics. Inability to see the bottom of swimming pools and lakes when diving or wading can result in serious injury, while muddy water reduces the enjoyment for both swimming and boating. A desirable objective is that Jackson turbidity units be less than 25 under conditions where quality control can be exercised. In swimming pools, the water should have sufficient clarity for a black disk, 6 inches in diameter, to be readily visible when placed on a white field at the deepest place in the pool. (5)

### 4. Growth and Propagation of Fish and Other Aquatic Life.

The problems of identifying and describing the influence of sediment on aquatic life is indicated by the variety of data on this subject. Certain degrading effects on spawning and habitat have been clearly established, without necessarily providing qualitative values. The effect of sediment on the aquatic environment includes inhibition of photosynthesis, destruction of benthonic organisms and damage to fish, as described by Hoak (6). Sunlight is essential for the synthesis of organic matter by plants and chlorophyll-bearing organisms. Data by Ellis (7) shows that turbid water reduces light penetration about 50 percent and muddy water, about 75 percent. Deposition of sediment on a

stream bed can have several damaging effects. It tends to smother both organisms which contribute toward purification of the stream and those which provide food for fish. Fine sediment tends to clog the pores in gravel bed streams. This reduces the circulation of oxygen-rich water which sustains the viability of eggs deposited for spawning by fish. In addition to these effects, Bartsch (8) has pointed out that inert particles in settling to the bottom carry organic flocs and absorb finely dispersed organic matter. This may create anaerobic conditions of an objectional nature, such as the boiling up of gases. Turbid water may provide for slightly cooler bottom temperatures, an advantage to habitat if temperature approaches a critical value.

Many reports have indicated that sediment can clog or cut the gills of fish and mollusks, resulting in serious injury or death. After an intensive study of the literature, Cordone and Kelly (9) have concluded that there is no universal answer as to whether sediment is directly harmful to fish, but that there is no question that it is damaging to feeding and spawning grounds. There is also strong evidence to indicate that the catch in trout fishing streams is small at fairly low suspended sediment load concentrations. Apparently the fish cannot see a lure at moderate or high concentrations.

#### 5. Agricultural Water Supply.

Sediment affects use for irrigation by sprinkler systems or surface application, for injection or spreading of water for underground recharge, and for consumption by livestock.

In sprinkler irrigation, excessive wear of nozzle heads and fittings occurs when sediment of very fine sand (0.074 mm.) or coarser size is present in the distribution system. The extent of wear by concentrations of silt size particles is not known, but a minimal concentration of fine sediment is deemed desirable. In spreading of water for recharge, Schiff (10) has reported that a sediment concentration up to 575 ppm. has been handled when a grass cover maintained an open, friable surface soil, but that water with the same sediment concentration reduced infiltration rates drastically on nearly bare ground with the same soil. Other experience has indicated that extended application of water with concentrations exceeding 200 ppm. tends to clog pore spaces and lowers the efficiency of application. In the use of injection wells for ground water recharge, even a small amount of sediment may reduce the intake rate substantially.

In diversion of irrigation water, the water-sediment mixture is frequently in the same concentration as in the stream flow. The coarser sediment sizes then deposit in canals and diversions and the fine materials in laterals, farm ditches and fields. A minimum cost of maintenance for these installations would require relatively clear water, particularly exclusive of all sand sizes and gravel.

## THE EFFECT OF SEDIMENT ON WATER QUALITY IN NEW MEXICO

According to an inventory by the U. S. Public Health Service (11), there are about 6 communities in the State where a major or exclusive supply of water is from surface diversion or storage. The population served by these facilities is about 53,850, of which 25,000 are in the City of Farmington. The other approximately 250 communities and industrial users obtain their water from wells or springs. The subsurface supplies being used as the principal source in New Mexico are free of sediment. Each of the communities using surface supplies, with the exception of Las Vegas, have sedimentation treatment installations to eliminate both inert particles and flocs of dissolved solids. Sediment concentrations are relatively low where surface runoff is used, except in the northwest part of the State.

Sediment is one of several causes of limited recreational use, including swimming and fishing, of many New Mexico streams. The intense storms that occur during the summer when enjoyment of the streams is possible produce by far the heaviest sediment yields of the year. In addition to high concentrations of suspended sediment which move through the system, stream beds are covered by an undesirable layer of soft sand which has been brought in over geologic and modern times. According to the Proposed Water Quality Standards for the Rio Grande River in New Mexico (12), the river above the mouth of the Chama and the Chama above El Vado Reservoir are good to excellent fishing streams; Elephant Butte Reservoir and downstream to Percha Dam are excellent for warm water fishing. The stream reaches that make for good fishing and other recreational pursuits also coincide with contributing watersheds that have the lowest erosion in the State. The major reservoirs provide sufficient capacity for stored water to become clear through deposition of incoming sediment.

Sediment probably has its greatest impact in New Mexico on the quality of water used for irrigation. Accumulation in canals, laterals, and farm ditches requires cleanout, and deposition on fields reduces permeability or requires releveling for efficient water application. A sampling of the cost of cleaning sediment from farm ditches in the Rio Chama-Espanola watershed indicated that the cost per cubic yard averages about 76¢ for earth lining and \$2.00 for concrete lined ditches. A cubic yard is equivalent to about one ton of sediment.

Figure 1 shows the location of principal areas irrigated by surface water or a combination of surface and ground water as related to major sediment source areas. The data were obtained from maps prepared at New Mexico State University (13) and by Thorp (14).

An analysis is being made to determine the principal factors which contribute to reservoir sedimentation in the western part of the country. Preliminary results that have been published (15) point up the reasons why much of New Mexico is highly vulnerable to erosion. These include

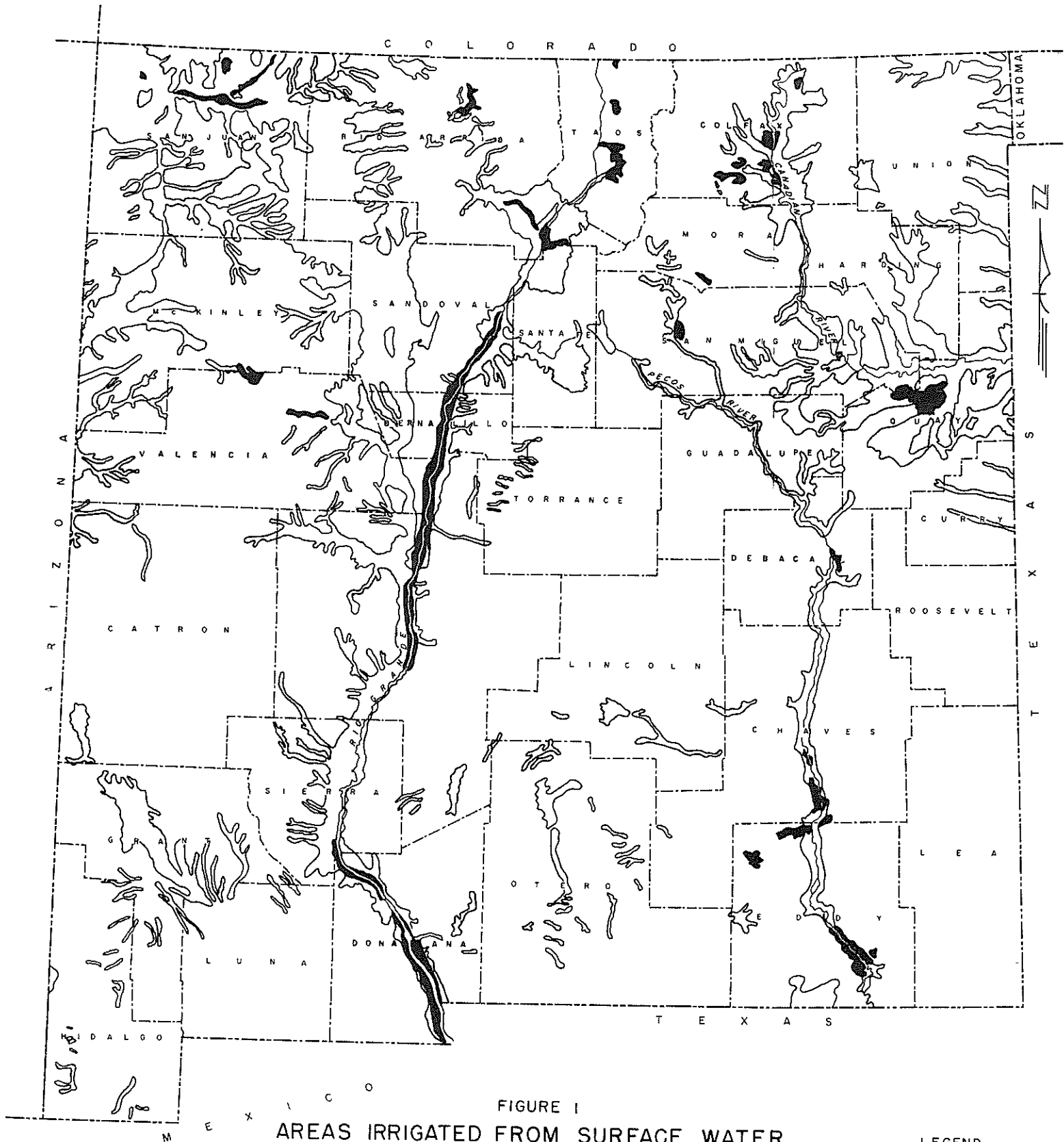


FIGURE 1  
 AREAS IRRIGATED FROM SURFACE WATER  
 RELATED TO MAJOR SEDIMENT SOURCE AREAS  
 NEW MEXICO  
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Approximate Scale in Miles

- LEGEND
- Land irrigated with surface water or with surface and ground water.
  - Major sediment source areas.

a limited amount of moisture for plant growth, moderate to steep terrain with a relatively high drainage density, and very unstable soils. The studies indicate that salts in the soils contribute to their erodibility. It is suggested that the marked increase in dissolved solids in water of the Rio Grande during the summer storm season is linked to the high erosion that occurs over most of the basin. This cause of increase would be in addition to removal of the salt crust which develops on the soil surface from capillary action. Erosion exposes new layers of underlying salty subsoil and parent material. Dortignac (16) has pointed out the attendant relationship between increased salt content and increased sediment concentration in streams. The climate, topography and soils which are the major elements contributing to the high sediment load of New Mexico's streams create a watershed condition highly sensitive to relatively minor disturbances.

The proposed Water Quality Standards for the Rio Grande excludes from pollution subject to regulation, turbidity which is naturally caused by silt and suspended sediment or from the operation of irrigation or flood control facilities. The proposed standards for the Pecos River (17) exclude silt and suspended sediment but not other "significant sources of turbidity" as subject to abatement. These recommendations understandably recognize the problem of abating sediment concentrations by attempting control of natural phenomenon with regulation. The Soil Conservation Service in December 1966 suggested changes be considered for the proposed Water Quality Standards for the Rio Grande. These changes include a recommendation that "Naturally occurring turbidity caused by silt and suspended sediment or from operation of irrigation, flood control facilities, or land treatment measures are not subject to regulations unless more efficient and economical measures could be instituted to alleviate the turbidity conditions. Then the turbidity would be subject to these regulations."

The above proposal recognized that there is a potential for reduced sedimentation in New Mexico streams. In evaluating the effects of land treatment, it is generally assumed that the best one can do in reducing erosion is to return it to the so-called normal geological rate. As one facet of the effort to make such an interpretation, much has been written and discussed about the origin of valley trenches which have contributed so substantially to high sediment yields of watersheds such as the Rio Puerco. Speculation on such topics does not rule out the fact that the potential for sediment control can be classified by sites in such categories as those subject to agronomic or management measures or subject to structural measures, or combinations of these, and finally those sites not subject to control.

It is possible to estimate quantitatively the reduction in sediment yield by installation of measures for stabilization or control of sources. Evaluation of benefits in terms of improved water quality may be simple or complex, depending upon the physical conditions and the standards which must be met for specific water uses. Benefits of treating an identifiable

source of water-born sediment depositing in a canal or entering a domestic water supply system may be easily determined. As the types and sources for degrading sediment become more numerous it is necessary to determine the proportionate contribution of each source to the problem. Benefits would be reduced costs of removal or of water treatment. However, certain uses require that water quality be of a specific standard on arrival at the place of use. Stream recreation and fish habitat are of this type. The option of treatment immediately before or sediment removal after the use may not be available. In these instances it will be necessary to first determine whether watershed treatment can reduce sediment concentrations to acceptable standards for the specific use. The economic feasibility of physically effective measures must be judged on the basis of their downstream impact, of which water quality is one, and on their on-site benefits.

#### SUMMARY

Water quality standards pertaining to sediment indicate that turbidities or concentrations must be very low for municipal and industrial use and only slightly higher for recreational use, including sport fishing and swimming. For supplies of municipal and industrial water New Mexico is fortunate in that the major source, ground water, is generally free of sediment. However, irrigation water, drawn chiefly from surface supplies, is usually high in sediment concentrations and in damage to distribution systems. Opportunities exist for reduction in sediment yield. Certain programs in this field, not otherwise justified, may be feasible with the added benefits of water quality improvement.

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