NATURAL RESOURCES JOURNAL

Volume 18
Issue 1 *Symposium on U.S. - Mexican Transboundary Resources, Part II*

Winter 1978

Interrelationship of Ground and Surface Water Quality in the El Paso-Juarez and Mesilla Valleys

John W. Hernandez

INTERRELATIONSHIP OF GROUND AND SURFACE WATER QUALITY IN THE EL PASO-JUAREZ AND MESILLA VALLEYS

JOHN W. HERNANDEZ*

THE RIVER SYSTEM

The section of the Rio Grande in question begins at San Marcial, New Mexico, at the head waters of Elephant Butte Reservoir and extends to Fort Quitman, Texas, at the end of the system. The river run in this stretch is about 250 miles. Approximately half way down the river, the river valley pinches in, at the El Paso narrows, where Texas and New Mexico meet at the U.S.-Mexico border.

This reach of the Rio Grande includes two large reservoirs, Elephant Butte and Caballo, that store water for irrigated agriculture in New Mexico, Texas, and Chihuahua, Mexico. The irrigated lands lie in the narrow valleys of the Rio Grande trough and include the 155,000 acres of the Bureau of Reclamation's Rio Grande Project. In addition, there is land in Mexico below Juarez that is irrigated from the 60,000 acre-feet allocated to Mexico by the Treaty of 1906. There are also the Hudspeth County irrigated district lands, below El Paso but still within Texas, that utilize the excess flow from the Rio Grande Project.[1]

Prior to construction of Elephant Butte Dam, the Rio Grande could not be used to maintain a large irrigated area because of the variability of its seasonal flow. The only months in which there was a significant runoff were April, May, June, and July. During the rest of the year, the flow was on the order of 20,000 acre-feet per month. During periods of peak runoff, however, there were high volume flows in the river, which resulted in a situation that was not conducive to irrigation due to the use of brush dams that were the state-of-the-art in water management at the time. The year-to-year distribution of annual flows at Elephant Butte is quite variable, ranging from 2½ million acre-feet in some years to smaller amounts on the order of 60,000 acre-feet in others. The numerical value for average flow is

---

*Dean of the College of Engineering, New Mexico State University.

1. For more detailed information about this region, *see* J. Hernandez, Rio Grande Water Quality Base Line Study 1974-75 For the Rio Grande, Canals and Associated Dams From San Marcial, New Mexico to Fort Quitman, Texas, N.M. Water Resources Research Inst. Report No. 064 (1976) [hereinafter cited as Hernandez]; *see also* R. Lansford, An Analytical Interdisciplinary Evaluation of the Utilization of the Water Resources of the Rio Grande in New Mexico, N.M. Water Resources Research Inst. Report No. 020 (1973).

shifted quite far above the median value. The average volume of water that has historically been available in these two lakes for release for irrigation has been almost 800,000 acre-feet per year. The amount of water available for irrigation use in the past twenty-five years has been markedly less than that in the first twenty-five years after the construction of Elephant Butte Dam.

An analysis of the change in the discharge into these two reservoirs over time can be made using ten year averages. Beginning about 1900, the ten year moving average at Elephant Butte was about 1½ million acre-feet per year. The flow has gradually declined to where the ten year moving average is now on the order of 600,000 acre-feet per year.[2]

SURFACE WATER QUALITY

There are a number of interesting questions that may be asked with respect to surface water quality. For example, does the quality of the water change greatly proceeding downstream from Elephant Butte toward El Paso-Juarez? Given an average year, the flow of water into reservoirs is about 600,000 acre-feet and the dissolved solids content is on the order of 0.6 to 0.7 tons per acre-foot. By the time the irrigation releases reach the Mesilla Valley, the content is 0.7 to 0.8, and at El Paso about 1.0 to 1.2 tons per acre-foot. When the residual flow reaches the end of the system at Fort Quitman, the salts amount to 2.5 to 4 tons per acre-foot.[3] These values represent typical conditions and not long-term averages.

Does the quality of the water depend on the volume of flow in the river system? Absolutely, but with a few reservations. The higher the flow in the river, the better the quality. Typically, there is a log-log relationship between flow and quality that holds for many parameters at most of the sampling stations on the Rio Grande.[4] At periods of low-flow when there are no releases of water being made from Caballo Reservoir, the total dissolved solids content of the river is quite high, approaching that characteristic of shallow ground water. During low-flow years there is a salt build-up on the irrigated lands, resulting from a lesser availability and slightly poorer quality of water and from decreased return-flows. The dissolved solids that are held on the land are then flushed out during the first high-flow years after a

2. *See* N.M. Environmental Improvement Agency, Lower Rio Grande Basin Plan, 1972 (1972) for additional details on changes in the annual flows into Elephant Butte.

3. Approximate calculations based on information in Hernandez, *supra* note 1, at app. B.

4. The initial version of New Mexico's interstate stream water quality standards (1967) for the Pecos and Rio Grande were developed utilizing this type of relationship, Hernandez, *supra* note 1.

drought period. During years of low-flow, farmers use increased amounts of well-water, which is of a lower quality, and this contributes to the build-ups of salt on the irrigated lands.

What are typical quality characteristics of the surface flow at various points along the river at the present time? During 1975, five sets of samples were collected at 45 different stations along the Rio Grande in the reach in question, and were analyzed for a number of physical, biological, and chemical parameters. This sampling program was made by New Mexico State University under a contract with the U.S. Bureau of Reclamation in order to provide a base line for the various water quality parameters.[5] The stations sampled included the reservoirs, the river at a number of points, the irrigation drains, some canals below El Paso, and the waste-water treatment plant effluents of communities along the Rio Grande in New Mexico and Texas. A summary of some of the more interesting data from the report submitted to the Bureau of Reclamation is given in the subsections that follow.[6]

1. Chemical Oxygen Demand (COD)

The COD of samples collected on the Rio Grande above Las Cruces is less than 100 mg/1 except during periods of high runoff. When high runoff occurs, settled samples will yield COD values below the 100 mg/1 level. Below Las Cruces, the COD of river samples can exceed 100 mg/1 at times, but typically these stations yield a COD below that value. Higher COD values can be found for the drains during periods of runoff, but the average dry weather COD of the drains appears to be lower than that of river samples. The canals at the lower end of the Rio Grande Project yielded higher average values than that expected in the drains or the river. This is borne out by the physical appearance of these samples; they are characteristically turbid and colored. There is great variability in the COD values for the sewage effluents from the plants sampled. Some plants were consistently high and some consistently low. With a few exceptions, all of the results indicated unacceptably high COD values, even from the best plants. A need for improved performance, in order to obtain COD values of less than 100 mg/1 is evident. A number of the plants were under construction during the time of the survey.

2. Coliform and Fecal Coliform

The result for river and reservoir samples yielded values that

5. A detailed description of sampling procedures, frequency and stations is given in Hernandez, *supra* note 1.

6. The basic data from this survey is reported in Hernandez, *supra* note 1, at app. A.

ranged from zero during some sampling runs for Elephant Butte and Caballo Reservoirs, and for the river just below these two lakes, to half a million coliform at a number of stations on the Rio Grande. The highest values were obtained during a period of high runoff; bacterial levels increased from values on the order of hundreds or less to numbers on the order of a quarter of a million or more. Comparison of the results for the September period of high runoff and the October period of normal conditions shows the marked effect of storm flow on bacterial quality in the Rio Grande. In general, the bacteria count per 100 ml increases with increasing distance downstream. As in the case of COD results, the drains are somewhat, but not as greatly, influenced by storm runoff as the flow of the Rio Grande. There does not seem to be as wide a variation in bacterial numbers; counts in the lower range are generally much higher in the drains than in the river samples and the higher values for the drains are an order of magnitude lower than the high values for the Rio Grande. Dry weather counts for coliform for many of the drains range from 500 to 5,000. Two drains had relatively high fecal coliform levels, in the Hatch drain and the East Drain near La Tuna. Municipal wastes are the cause of high counts.

Counts for both coliform and fecal coliform for the canals at the lower end of the system exceed those in the drains and in the river samples. This coincides with COD data. The region's sewage treatment plants yielded the highest counts. In general, the levels for both coliform and fecal coliform from the treatment plants were extremely high, with only a few plants ever reducing levels below 10,000 coliform and 5,000 fecal coliform per 100 ml. As there are some very serious questions about the chlorination of sewage effluents and as the return flows are used for irrigation of various crops, some of which are eaten raw, additional monitoring for these two parameters appears to be warranted.

3. *Total Dissolved Solids and Conductivity*

These parameters measure the soluble ions in solution in a sample, although conductivity is not as precise a parameter because the particular ions present can alter the relationship of conductance to TDS. This is particularly true for the variety of waters that flow into the Rio Grande within the Project bounds because they are derived from many sources. An analysis of the ratio of these two parameters for each of the stations sampled would be useful as a check on future quality. A visual comparison of the graphical presentations of conductivity and TDS shows that they vary in similar patterns.

In general, the concentration of TDS and conductivity increases in river samples taken downstream. The TDS and conductivity of drain samples are subject to much less variation over a period of a year than are river samples, but this is not true for drains at the lower end of the Project. Canal samples, however, vary more than do drain samples. During periods of high-flow, the quality improves when gauged by these two parameters.

4. *Common Cations and Anions*

One characteristic typical of all of the common ions is that a general relationship to TDS and conductivity can be seen in most samples. This relationship is not a consistent one, however. During periods when there are no releases from Elephant Butte and Caballo reservoirs, concentrations of both anions and cations increase in samples collected from the Rio Grande below these two lakes. Quality during low-flow is much poorer in terms of common ions than during periods when there are water releases and storm discharge. The seasonal variations in quality become greater in river samples taken at the lower end of the river as compared to those taken from upstream stations.

In general, the concentration of anions and cations increases significantly in river samples with increasing distance downstream. For example, the sodium concentration during periods of water release from Elephant Butte and Caballo reservoirs is typically less than 100 mg/1 above Mesilla Dam, while below this point it is characteristically above 100 mg/1. These figures indicate that sodium concentration progressively increases. Part of the reason is the concentration of sodium in the drain return-flows. Typical values for drains above Las Cruces appear to be 200 mg/1 $\pm$ 50 mg/1, while drains below Mesilla Dam have sodium concentrations above 250 mg/1, with some values twice as high. Sodium concentration in waters at the end of the Rio Grande Project are very high; values over 500 mg/1 are not uncommon.

5. *Nutrients and Surfactants*

Nutrients in surface waters become a problem due to excessive algal blooms and the growth of weeds and other vegetation. The presence of unusual or excessive amounts of nutrients may be used as an indicator of pollution, particularly from domestic and municipal sources. This also is true of the presence of surfactants (synthetic detergents).

By and large, analysis for detergents (LAS) indicated that only a few sampling stations had unusually high values, and that these were effluents from municipal wastewater treatment plants. Background values in the Rio Grande and its drains are on the order of 0.02 mg/1, as a result of naturally occurring substances that interfere with the test, while the values for LAS from wastewater plants are significantly above 0.02 mg/1. Waste treatment plants with good biological treatment registered relatively small, but typically above background, amounts of synthetic detergents. The few values that were above the milligram per liter level were from the two plants with biological treatment units that were functioning poorly, if at all.

Variations in total nitrogen are not necessarily mirrored in the levels of nitrate-nitrogen that are present in various samples. In river samples during periods of reservoir release (June), there is 1.5 to 3.5 mg/1 of total nitrogen and almost no nitrate-nitrogen while at low-flow conditions (December), the total nitrogen content is on the order of 0.5 to 0.15 mg/1, and virtually all of it in the nitrate form. At low river flows, water temperature, sunlight, turbidity, velocity of flow, and other environmental factors tend to permit formation of higher percentage concentrations of nitrates relative to total nitrogen. A similar situation exists in many of the drains, but no generalization can be made. Even greater variations in the ratio of nitrates to total nitrogen may be observed for sewage treatment plant effluents. There were many effluent samples from treatment plants during the sampling year that yielded total nitrogen values on the order of 20 to 40 mg/1. For these same samples, the nitrate-nitrogen levels ranged from 10 to 20 mg/1 to values of 0.1 mg/1 or less.

Another measure of the nutrient potential of water is the total phosphorus content, designated as *P*. *P* is also a good indicator of pollution because of the presence of phosphates in synthetic detergents. No readily discernible pattern of change was evident for river samples, although variations on the order of a factor of ten are not uncommon; concentrations range from 0.01 to 0.4 mg/1 at river stations. The drains and the canals show similar unrelated variations, but with higher concentrations in the canals at the lower end of the irrigation system, ranging to 6 mg/1. This should not be too surprising, as the canals are fed by return flows from the irrigated lands and by some municipal sewage effluent. Phosphate levels in plant discharges are significantly higher; concentrations from 2 to 10 mg/1 are common. For these effluents, there is a similar pattern of change at the different plants with *P* values for the September and December sampling periods being typically higher than those during the other three sampling periods.

6. *Trace Metals*

Analyses were run for a number of trace metals, as they are indicators of agricultural, industrial, and municipal contamination of surface waters. These elements included copper, mercury, zinc, cadmium, arsenic, and lead. The only sampling points that registered noticeably higher values for these trace metals were the municipal wastewater discharges and some of the drains and canals at the lower end of the Rio Grande Project irrigation system, the Border Intercept Drain, Hudspeth Feeder Canal, and the Tornillo Drain. The highest levels in the drains and canals are for lead; these concentrations possibly could be the result of urban air pollution in the El Paso area. A number of the values for lead in the lower drains and canals exceed the drinking water standard of 0.05 mg/1, and there are one or two analyses that are significantly higher.

GROUND WATER SYSTEMS AND QUALITY

There are several distinct ground water basins and systems along the Rio Grande, between Elephant Butte and Fort Quitman. Although there are interconnections, the more important basins have relatively little water interchange with each other. The most important ground water units, because of their use and the magnitude of their resources, are the Mesilla Valley above the El Paso narrows and the Hueco Bolson below.[7]

The Hueco Bolson is an artesian aquifer shared by Juarez and El Paso and there is a fresh water-saline water interface that is maintained by aquifer pressures. As noted by Day,[8] water levels in the artesian zone have declined because of heavy pumping, resulting in increased salinity. There is no known direct interconnection between Rio Grande surface waters and ground water in the Hueco Bolson.

The river does influence the quality for the shallow ground water system in the El Paso and Juarez valleys. The quality of the valley free surface aquifer is quite poor and is characterized by the quality of the drains and canals that transverse it.

The Mesilla Valley starts at a narrow section of the river near Radium Springs, New Mexico, and continues southward about 50 miles to the El Paso narrows. At that end there is an outcrop of andesite that effectively dams the Rio Grande, although the sill is below the present river grade. There is reported to be very little natural ground water discharge from the Mesilla Valley into the Rio

7. R. Lansford, *supra* note 1, reports analytical evaluations of the ground water potential in the many basins that make up the Rio Grande in New Mexico.

8. Day, *Urban Water Management of An International River: The Case of El Paso-Juarez*, 15 NAT. RES. J. 454 (1975).

Grande at the El Paso narrows; in 1907 it was estimated to be less than 50 gallons per minute.[9]

The Mesilla Valley aquifer is of variable width and of unknown thickness. Its areal extent has not been determined fully, but this is the subject of an ongoing study by the U.S. Geological Survey. Water quality is quite variable, with lenses of markedly better quality water being found in different areas at different depths. Generally, water quality deteriorates approaching the Organ-Franklin side of the valley fill. There are areas where alluvial fans from these mountains adversely affect quality. There also are zones where geologic activity has a pronounced, but limited, effect.

CONCLUSION

The quality of the surface flow in the Rio Grande is of great interest to the U.S. and Mexico, and it is important that analytical studies on historical water quality records be carried on so as to detect changes in quality before serious adverse effects occur. There is little or no connection between the quality of the surface flow and the better zones of the two major aquifer systems in the El Paso-Juarez area.

RESUMEN

La gente que viven en los tres estados y dos paises que tocan en el Rio Bravo en el área de El Paso-Ciudad Juárez comparten un ambiente común; sufren la misma contaminación de aire, distribuyen los mismos recursos aquíferos, en calidad si no en cantidad, son víctimas de los mismos mosquitos, usan las mismas facilidades para recreo, y se gozan de las mismas vistas y paisajes. Todas estas calidades comunes tienen sus propios problemas y la administración de estos problemas es uno de los desafíos más significantes que ya confronte a los administrativos en los tres estados mencionados.

La calidad de aguas superficiales y aguas subterráneas en la región tiene varias ramificaciones correlativas. Este trabajo examina un estudio hecho en 1975 bajo la administración del Bureau of Reclamation de los Estados Unidos sobre la calidad de las aguas superficiales (el río, y los drenes, canales y descargos) del Río Bravo desde San Marcial, New Mexico, hasta Fort Quitman, Texas. Se presenta datos sobre los característicos químicos, biológicos y físicos de estas aguas superficiales.

Una de las consideraciones a lo largo de esta área de 250 millas es la

9. G. Richardson, Water Table Investigation in the Mesilla Valley, N.M. St. U. Engineering Experiment Station, Tech. Rep. 76 (1972).

relación recíproca entre la calidad de las aguas superficiales y los mayores recursos de aguas subterráneas en la región. Las conclusiones de este trabajo son las siguientes:

1). que la calidad de aguas superficiales influye la calidad de las aguas subterráneas pocas profundas en las areas de los valles.

2). que estas aguas subterráneas pocas profundas tienen más sales que las aguas en areas más profundas de los valles.

3). que se pueden usar la calidad de los drenes para extrapolar la calidad de las zonas cerca del superficie; y

4). que hay poca relación entre la calidad del flujo superficial y las zonas de mejor calidad en los mayores sistemas acuíferos artesianos en el área de El Paso-Juárez.