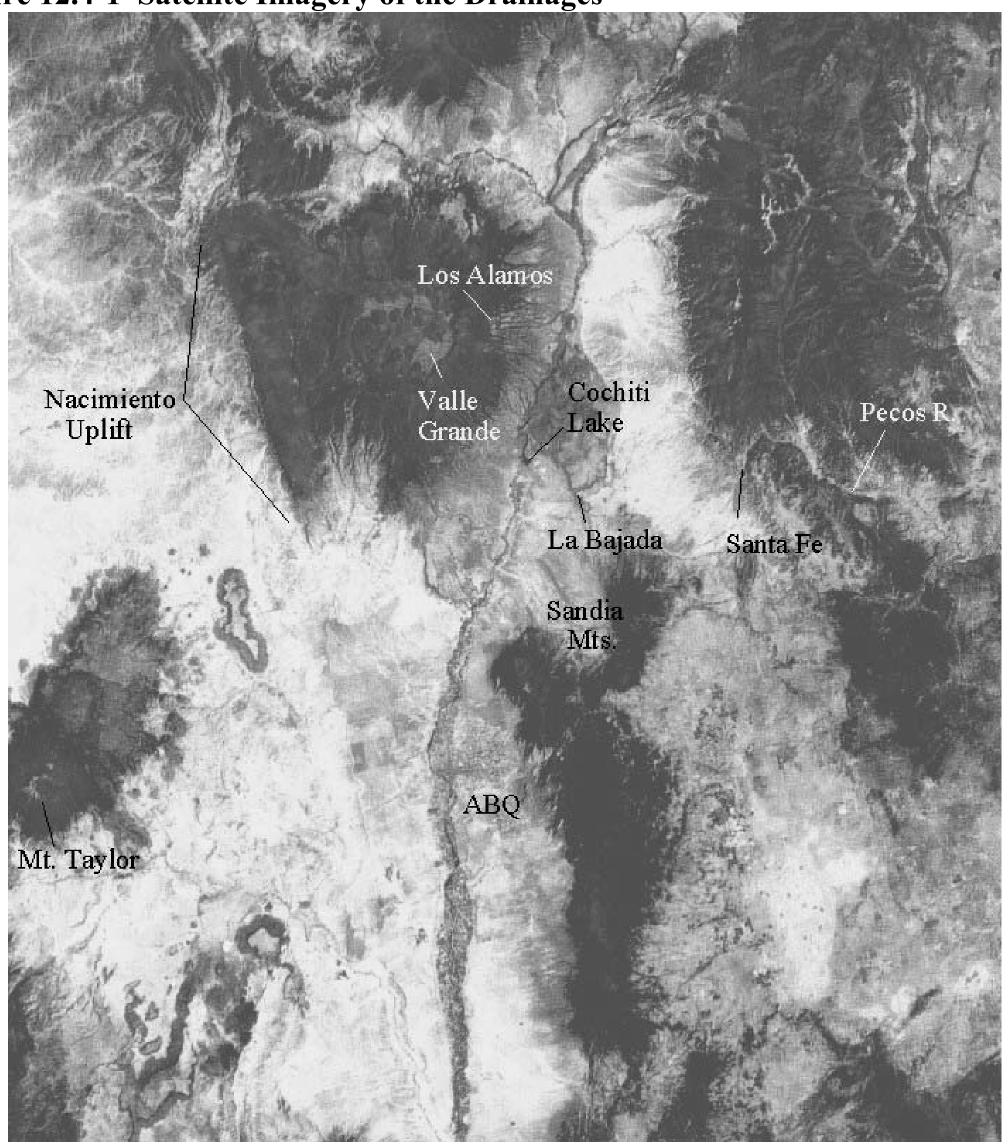
# 12.4. PHYSICAL CHARACTERISTICS OR WHY WE LOOK THE WAY WE DO

## 12.4.1. Introduction

The past is the key to the future. By knowing environmental conditions that operated in the past, better predictions can aid with planning. Geology provides the background for both the Río Puerco and Río Jemez. To a great degree, it guides the way an area develops, considers the slope and soils found, as well as affects of climate, due to altitude and precipitation. This summary of the watersheds, to be augmented in the future, will give context to the regional water plan.

**Figure 12.4-1 Satellite Imagery of the Drainages**




Source: Middle Rio Grande Basin Study, February 1999, James R. Bartolino, ed.

The mountains known as the Jemez are really two geologically different areas: the remnants of a giant volcano that erupted and collapsed a million years ago and the Nacimiento Uplift, a derivative of the same mountain building process, which built the Rockies more than 65 million years ago.

### 12.4.2. Río Jemez

**Figure 12.4-2 A Volcanic Beginning**


**Figure 12.4-3 - Photos from the Top of the Watershed**

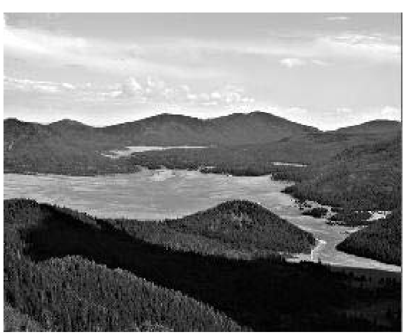


Photo Credits:
1. www.ronbrownrealty.com
2. Dennis Smith, Jemez Springs
3. www.fs.fed.us/r3/sfe/districts/jemez/index.html

The Jemez Mountain range is isolated from the Southern Rocky Mountains by the Rio Grande valley and possesses a number of unique species. Furthermore, the Jemez Mountains support a number of ecosystems due to the great elevation range and variety of soil types and climatic regimes. There are 870,395 acres in the Jemez range, of which 78.3% is federally administered, 21.4% is privately owned, and 0.3% is state-owned (McCarthy 2002).

#### *12.4.2.1. Army Corps of Engineers Report*

A report was issued recently by the Army Corp of Engineers. Relevant information is set out verbatim in this section. Complete report is in Appendix B.

Final Environmental Assessment for the Proposed Construction
of a Low-Head Weir, Río Jemez, The Pueblo Of Santa Ana, New Mexico

U.S. Army Corps of Engineers, Albuquerque District
August 2003

> The Río Jemez flows in a generally southeasterly direction with a total length of approximately 65 miles. Elevation ranges from over 11,000 ft. at the headwaters of the watershed to 5,075 at the confluence with the Río Grande. The river is perennial in the upper reach and ephemeral in the lower reach above the Jemez Canyon.
>
> Geomorphology
>
> The total area drained by the Río Jemez is 1,038 square miles, with 1,034 square miles above the dam. The watershed is about 65 miles long with a maximum width of 30 miles. The terrain rises from elevation 5,120 feet at the dam to over 11,000 feet in the mountainous region of the headwaters in the Jemez Mountains. The stream channel in the upper reach is confined within narrow canyons. The stream meanders through a broad sandy valley in the lower reaches and through the reservoir area which is several hundred feet wide without well-defined banks. Below the dam the river enters a narrow canyon, which extends to the confluence with the Rio Grande. Stream slopes vary from 0.3% at the dam to greater than 4.7% in the mountains.
>
> The Río Jemez at the [weir construction] project impact area can be classified as a Rosgen D5 stream type (Rosgen 1996). A D5 river/stream is characterized by braided streams within a broad alluvial valley and an alluvial fan consisting of deposited sand-sized material. Channel bed materials are predominantly sand with interspersed amounts of silt/clay materials on deltas. The braided channel system is characterized by high bank erosion rates, excessive deposition occurring as both longitudinal and traverse bars, and annual shifts of bed location. Bed morphology is characterized by a closely spaced series of rapids and scour pools formed by convergence/divergence processes that are very unstable. A combination of conditions are responsible for channel braiding, including high sediment supply, high bank erodibility, and very flashy runoff conditions which can vary rapidly from a base flow to an over-bank flow on a frequent basis (Rosgen 1996).

The principal mountain tributary of the Río Jemez is the Río Guadalupe, which enters the river about 26 miles upstream from the dam. It originates in the Jemez Mountains and is perennial. Coniferous forest, interspersed with groves of aspen, covers the watershed above 7,000 feet. Vegetal cover in the lower elevations includes pinyon pine, juniper, and oak brush with very sparse grasses and forbs. The upper area is characterized by steep slopes varying from 250 feet per mile to 130 feet per mile, which results in rapid runoff.

The principal tributary in the lower basin is the Río Salado, an ephemeral stream, which drains the southwest portion of the Río Jemez Basin. It originates in the lower mountain region and flows through the highly erodible, low-lying plateau area of the watershed. Vegetal cover is sparse and consists of short grass and desert shrubs. Slopes in this area vary from about 2.5% at higher elevations to 0.3% along the Río Jemez delta. Because of the nature of the soils and plant cover, the lower area is much more conducive to runoff than the upper area. The Río Salado-Río Jemez confluence is near San Ysidro about 17 miles upstream from the dam.

Sedimentation

The Río Jemez above its confluence with the Río Salado at San Ysidro has a drainage area of about 600 square miles. From sediment sampling records between February 1937 and June 1941, suspended sediment passing San Ysidro was approximately 400 acre-feet per year and the average concentration for all months of record was 0.46% sediment by weight. Some sediment was diverted into irrigation ditches at San Ysidro. No known sediment samples were secured from this location between 1941 and 1975 (USACE 1975).

The Río Salado has a drainage area of about 251 square miles, most of which is plateau with rough, broken and hilly terrain, and is easily eroded. For about three miles above San Ysidro, the streambed is wide and sandy. Sediment sampling on this stream showed that the sediment load was about 150 acre-feet per year including 15 acre-feet of bedload. Records of sediment sampling from the Río Jemez at Zia Pueblo, about five miles below the Jemez-Río Salado confluence, show an average annual suspended sediment load of about 500 acre-feet per year (USACE 1994).

Below San Ysidro, the characteristics of Río Jemez suddenly change. The slope becomes flatter and the streambed becomes wider and is plugged with sand and fine material, which is washed into the river from tributaries and aeolian deposition. The 183 square miles of drainage area between Jemez Dam and San Ysidro produces about one-half of the total sediment entering the reservoir area. Most of the sediment comes from the south side of the Río Jemez where the Santa Fe formation is exposed or is covered with a mantle of wind-blown alluvium. The surrounding area is sparsely vegetated. The terrain consists of rolling hills cut by numerous steep-sided arroyos. Near the river extensive dunes have advanced to the edge of the stream in some places. Runoff from this area discharges large quantities of sediment into the river. The suspended sediment load entering the reservoir area was estimated to be about 910 acre-feet per year and the bed load about 10% of the suspended load for a total of about 1,000 acre-feet per year. Approximately 60% of the total yearly runoff occurs during the spring runoff period and about 70% of the total suspended sediment load occurs during this period (USACE 1994) "

### 12.4.3. Río Puerco

The Nacimiento Mountains form the top of the watershed of the Upper Puerco. As part of the southern Rockies, they are not related to the volcanic caldera and mountains of the Jemez. The range is an uplifted plateau of granite. The flanks of the range are deeply incised, carved with abrupt canyons by streams draining the plateau. Much of the plateau is located within the San Pedro Parks Wilderness.

http://www.fs.fed.us/r3/sfe/recreation/wilderness.htm

SAN PEDRO PARKS WILDERNESS

In 1931, the Chief of the Forest Service classified a 41,132-acre area in the San Pedro Mountains of western New Mexico as a Primitive Area. Ten years later the Secretary of Agriculture recognized the land as a Wild Area. It wasn't until 1965 that the San Pedro Parks Wilderness was officially designated.

The defining features of the Parks are the large grassy meadows framed by dense stands of spruce and mixed conifer trees. Elk, deer, black bear, turkey and other wildlife call this expansive grounds their home. The San Pedro Parks is also open to cattle grazing for ranchers with permits.

The San Gregorio Lake is the main body of water in the Parks. Various streams cut through the meadows and mountains supporting the native Rio Grande Cutthroat population. Fishing and hiking in the Parks is a popular summer past time in the Parks. In the winter, cross-country skiing and snowshoeing is popular.

The San Pedro Parks Wilderness is located in the southern portion of the Coyote Ranger District and the northern portion of the Cuba Ranger Districts. Access is possible through both districts.

**Figure 12.4-4 Top of the Watershed--San Pedro Parks Wilderness**
(Size: 41,132 acres, Elevational range: 9,400 - 10,523 feet )

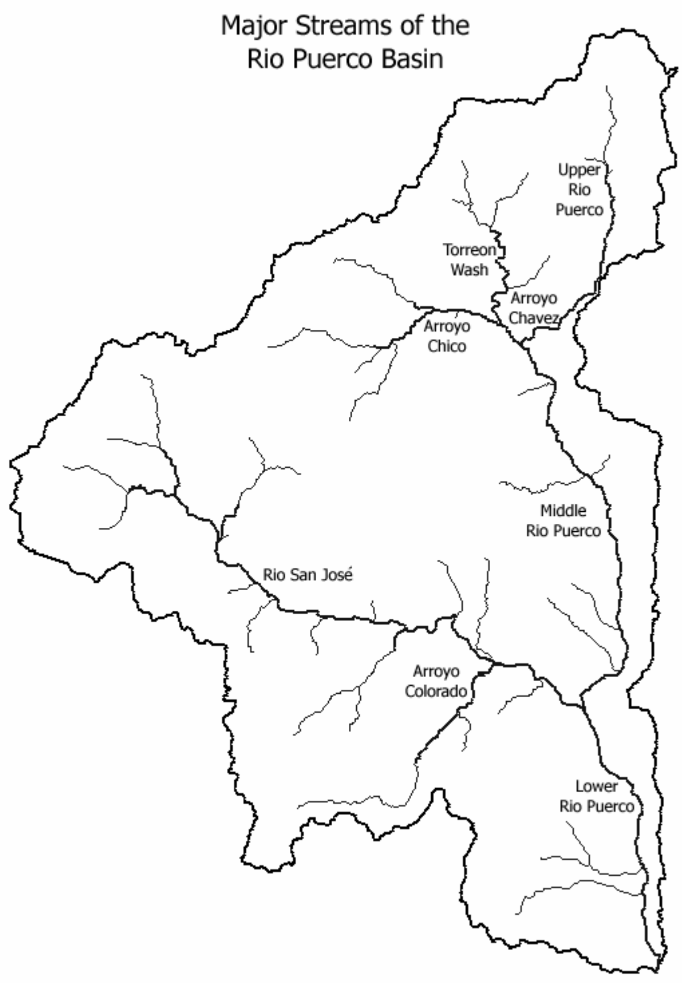
### *12.4.3.1. Río Puerco Online*

An excellent source of information on the Río Puerco can be found at *Río Puerco Online* <http://climchange.cr.usgs.gov/rio_puerco/>. The home page contains a synopsis of the information available, reprinted below:

<u>Río Puerco Online</u>

> The Río Puerco basin occupies roughly 16,000 km2 (6,220 mi$^2$) of northwestern New Mexico. Río Puerco is one of the main tributaries of the Rio Grande, entering the river near Bernardo. It supplies more than 70% of the suspended sediment entering the Rio Grande above Elephant Butte reservoir.
>
> The topography of the basin reflects the differential resistance of rock units to weathering and erosion. The highest parts of the basin drain Precambrian Granite of the Nacimiento range and basic volcanics of the Mt. Taylor Complex. Intermediate elevation mesas are on Mesozoic sandstones (e.g. Point Lookout Formation) and

**Figure 12.4-5 - Major Streams of the Río Puerco**



the lowest areas are on Mesozoic shales (e.g. Mancos Formation). The distribution of soils and vegetation is also influenced strongly by topography and geology. The average rainfall in the basin varies annually between about 12 to 20 inches, and is delivered mostly by the summer monsoon.

The Río Puerco is intermittent through most of its length with higher elevations receiving snowmelt and precipitation runoff events and lower reaches dominated by convective rainfall-runoff events. The large aerial extent of erosive geologic units in the basin provides a large source of available sediment to the channel. Happ (1948) estimated the sources of sediment in the Río Puerco as: 40% erosion of the existing Río Puerco channel (bed and banks), 30% erosion in tributary channels, and 30% sheet, rill, and minor gully erosion (Allen Gellis, History of Streamflow and Suspended-Sediment Collection in the Río Puerco Basin, New Mexico)

The Río Puerco Basin, New Mexico, is an area of historic arroyo incision, long-term geomorphic investigation, and ongoing land management issues. One cannot talk about the Río Puerco without talking about sediment. The USGS in conjunction with other federal and state agencies and Universities has established methods and sites for monitoring sediment yields in the Puerco. Allen Gellis has summarized the history of gauging and sediment collection and is developing a sediment budget for the Río Puerco.

Channelization has produced dramatic effects near La Ventana in the Upper Puerco. Impacts of the late 19th century arroyo incision, and subsequent sediment aggradation, can be documented through repeat photography. Historic photos from selected locations in the basin were obtained from the USGS photo archive in Denver, CO. Repeat photography was done in 1998.

Establishing long-term rates of sediment generation and erosion in drainage basins is critical in understanding the impacts of human and climate induced landscape change on the hydrology, ecology, and geomorphology of a region.

**Figure 12.4-6 - Cabezon Peak, a well-known landmark**

Photo Credit: Jennifer Johnson, La Jara

**Table 12.4-1 Summary of Sediment and Runoff Characteristics for USGS Gauging Stations in the Río Puerco Basin**

| Station | Period of Record* | Drainage Area (mi2) | Average Annual Suspended-Sediment Load (tons) | Average Annual Runoff (acre-feet) |
|---|---|---|---|---|
| Río Puerco above Arroyo Chico near Guadalupe (formerly referred to as Río Puerco below Cabezon) | 1949-55; 1982-96 | 420 | 860,500 | 10,500 |
| Arroyo Chico near Guadalupe | 1949-55; 1979-86 | 1390 | 1,931,600 | 17,300 |
| Río San Jose near Correo | 1949-55 | 2,670 | 533,400 | 10,100 |
| Río Puerco at Río Puerco | 1949-55 | 5,160 | 6,924,000 | 39,800 |
| Río Puerco near Bernardo | 1949-55 | 6,220 | 4,439,300 | 28,590 |

* Based on a water year, from October 1 of the previous year to September 30 of the current year.
Source: Allen Gellis, History of Streamflow and Suspended-Sediment Collection in the Río Puerco Basin, New Mexico,

**Figure 12.4-7 Río Puerco--Detail of Erosion**

Photograph of a collapsing wall of the Rio Puerco arroyo. Thousands of similar collapses along all sections of the arroyo place loose sediment directly in the stream channel. With such a constant supply, streams are fully saturated with sediment.

Photo Credit: Mike Chavez, Cuba

The Río Puerco, like many parts of New Mexico and Arizona, is affected by summer monsoons. These are moist flows of air that originate primarily in the Gulf of Mexico; the local manifestation is thunderstorms - exactly the sort of intense rain that can readily move materials and cut channels.

The Río Puerco is a tributary of the Rio Grande; at the confluence the Río Puerco contributes about 4% of the annual water flow and about 78% of the sediment.

**Figure 12.4-8 Río Puerco Arroyo Cycle and the History of Landscape Changes**

The Río Puerco near Cabezon in 1885 (photograph by E.A. Bass).

A photograph of the Río Puerco in flood by R.H. Chapman in 1905 shows the main channel to be unincised and flood flow is spread over at least a hundred meters of broad valley floor.

The same reach taken in 1977 (photograph by H.E. Malde).

When a valley is filled with fine sediments, as is the valley of the Río Puerco, erosion causes steep-walled gullies called arroyos. These channels significant barriers to transportation, access of livestock to water, and diversion of water for crop irrigation. The process of cutting arroyos into valley bottoms is called incision.

Río Puerco has not always had continuous arroyos. Prior to the 1880's, the area around the nearly abandoned town of San Luis was a broad flood plain. Annual renewal of soils by flood-borne silt encouraged vigorous grass cover. Historical accounts state that this was prime grazing land, and that residents of San Luis irrigated crops by diverting river waters into their fields.

Incision of the arroyo caused drastic changes. The river now flows entirely within the arroyo; without floods, the valley bottom supports desert shrubs rather than grass. Diversion of river water to fields near San Luis would have to originate far upstream, and it is impractical to maintain the needed diversion and transport structures.

As streams in the basin entrenched into the valley floor, the water-dependent riparian habitat shrank laterally and entrenched. Cottonwood trees, once prevalent in the valley bottoms, are now scarce. Reduction in wooded habitat has provoked an inevitable reduction in population of birds, grazing animals, rodents, and other species that depend on shade, food, and concealment provided by the riparian forest environment. Despite the reduction in riparian area, the arroyos and their terraces still support populations of mule deer, raccoons, coyotes, and other animals. In the many parts of the basin where arroyos are now refilling with sediment, terraces that store the accumulating sediment widen over time as a result of meandering of the channel within the arroyo. Much of the vegetation on these new terraces, however, is exotic: Russian olives and tamarisk (salt cedar) trees displace native cottonwoods. Thus, the current cycle of incision has caused significant changes in habitat and ecological resources of the basin.

In the mid-1960's the New Mexico State Highway Department established a new route for NM Highway 44 in the valley of the Río Puerco adjacent to the incised river channel between La Ventana and Cuba, New Mexico. The new route avoided a number of hills and created a flatter, wider and safer highway along the valley floor. The new highway alignment crossed sinuous meanders of the Río Puerco twice and skirted the outer margin of a third meander loop. Rerouting the main channel and eliminating the naturally sinuous meanders by channelizing a straight reach was seen as the best way to avoid considerable additional construction costs of at least two bridges.

A 1.1-mile reach of the Río Puerco upstream from La Ventana was channelized between 1965 and 1966. Channelization in a segment of the Río Puerco near La Ventana in 1965-67 led to geomorphic changes in the river. Channel slope before the channelization was 0.004 feet/ft. In 1997 upper portions of the channelized reach exceeded 0.008 feet/ft. The increase in slope led to dramatic vertical and lateral changes in the river. The channel has incised to depths over 50 feet. A 15 foot high knickpoint developed in bedrock of the Mesa Verde group. The rate of knickpoint migration measured with air photos indicates movement of 4 feet per year. Below the knickpoint the lateral erosion of the channel wall is 12.4 feet per year to a current width over 300 feet.

Based on changes in width and depth of the Río Puerco channel it is estimated that over 21,150 tons per year have been removed. As the knickpoint migrates upstream it is estimated that over 920,000 tons of sediment are produced per mile of channel. This represents 20% of the 4.44 million tons of suspended sediment transported annually by the Río Puerco to the Rio Grande.

Data sets . . . are being prepared for online distribution at the Rocky Mountain Mapping Center. Browse the Online Data Library for GIS coverages and aerial photos that are available for downloading and viewing.

For more information and further reading, please see:

- Erosion in the Río Puerco: Geography and Processes
- The Río Puerco Arroyo Cycle and the History of Landscape Changes
- The Arroyo Problem in the Southwestern United States
- From the Río to the Sierra: An Environmental History of the Middle Río Grande Basin, Dan Scurlock, 1998.