The Nature of Rivers:
The Rio Grande

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There is a lack of knowledge about what rivers actually are, how they form, their place in the water cycle, and river mechanics. Furthermore, most students in New Mexico will take no which courses that cover the subject of rivers from a geological, environmental or scientific standpoint other than the Earth Science class in middle school. Although APS does offer an Earth Science course in High School, it is one class among many options.

Rivers have historically been, and continue to be, of vital importance not only to humans and their societies but to many plant and animal communities as well. From ancient times to the present day, people have used river water for drinking, washing, irrigation, transportation, recreation, and to flush "away" unwanted materials. In more recent times, river currents have been utilized to provide indirect power by means of water wheels used to turn gears for mills, and later by turbines used to generate hydroelectric power.

Most people in our country no longer drink unprocessed water directly from the river; however, in many countries they still do. When I visited the New Orleans area I was told not to drink the water from the tap as it came from the Mississippi River and was loaded with carcinogens. If the water truly is hazardous, I'm sure there are many people who do drink it anyway, due to lack of information, judgement or money. Albuquerque residents enjoy some of the finest tap water in the country; it comes from the diminishing supply from the underground aquifer. But there are currently plans in the works for our future tap water to come from the Rio Grande River. I am assured by Steve Harrison at the Rio Grande Restoration project, that Albuquerque residents have nothing to fear – that the water quality (after purification) would be just as clean, if not cleaner, than the aquifer water. A few years back some people from the Office of the Medical Investigator visited my classes to do a statistical survey and to give an educational presentation. They brought in some deformed infant's skulls from a small village south of the border along the Rio Grande. The said it was a poor village and the birth defects seem to be a result of the villagers' dependence on the polluted Rio Grande river for their water needs. Some of the Indian Pueblo people are expressing concern over the use of the unclean water for irrigating their food crops for themselves and their animals.

There are other issues concerning the Rio Grande about which students and others should probably be more aware. These have to do with the health of the riparian forest or bosque along the river. The majestic Rio Grande cottonwoods, which are the dominant trees of the bosque, appear to be endangered. The threat seems to be there is not enough suitable habitat for the seedlings to make it to adulthood. The release of the seeds that are covered with a cotton-like material is synchronized with the timing of the spring floods along the river. Although this is an area of ongoing research, the main problem seems to be that the river is no longer flooding out onto its flood plain as was its previous yearly habit. Also, to make it to the sapling stage the roots of the seedling have to be able to grow to keep pace with the progressive lowering of the water table after the floods. The seedling's trials seem to be compounded by the fact that the water table is not as high as it used to be. This is presumably due to increased water use by people and industry. The bosque ecosystem is also threatened by the introduction of many non-native (exotic) types of vegetation; especially Tamarisk (Salt Cedar) and to a lesser extent Russian Olive trees.

Many animals that used to live in the river or bosque environment are no longer found there. It states in the Bosque Education Guide that " fifty percent of the fish that were once in the Rio Grande , are no longer found here." Rio Grande issues are very much in focus at this time. This is true not only in the Albuquerque area, but throughout New Mexico. Water, and especially clean water is becoming a very sought after commodity.

Since a significant number of our student's families come from Mexico, a unit that focuses on a river that runs from our area of New Mexico to Mexico, can foster a sense of connection and "shared place" between our two cultures.

Academic Setting

This unit is designed for a middle school Earth Science class at Polk Middle school. It will cover a

period of approximately fifteen days or class periods. Polk is located in the far South Valley of Albuquerque. The boundaries within which our student population lives encompass the South Valley (of largely Hispanic population), rural and agricultural, new housing developments, Isleta Pueblo, and Mexican communities. Our ethnic ratios are approximately 80% Hispanic (including Mexican), 10% Anglo, 8% Native American, and 2% African American of "other". Income levels vary along community lines with over 90% of the student population qualifying for free or reduced lunch.

The Rio Grande has historically been and is an integral part of the Albuquerque South Valley community's life. Polk is located about a mile west of the river. The Los Padillas Drain crosses Raymac Road just to the south of our school. The Arenal Main Canal and the Isleta Drain also cross Raymac a few blocks farther to the west. These drainage ditches eventually drain to the river and are also used for irrigation.

Rivers

Rivers are the drains of the land. The area of land that drains to a river is called a watershed or drainage basin for that river. Rivers are formed from water that runs over the surface of the earth. The run-off first forms small rills. These join to form gullies which further join to form small creeks or streams. These run together to form small rivers, which become tributaries to a main river. This natural form of river system formation has been likened to the branching pattern of a tree with the smaller branches on the outside (getting bigger as they get closer to the main trunk), or to the veins in a leaf, animal or human. It is referred to as the "dendritic" system or pattern of river formation.

The main river transverses its course from what is referred to as the "young river" stage (which is closer to the source, where the slope of the land is steeper and the water appears to run faster) to the "old river" stage. The old river flows, often meandering along its way, over land that is sloped more gently, eventually emptying into what is usually a sea or an ocean, but can sometimes be a lake or an underground cavern.

Geologic Formation of Rivers

Run-off water flows down to the lowest depression formed in the topography of the land. If the Earth's surface was smooth with no depressions or elevated areas, there would be no river formation. When several depressions exist they can fill to connect, or the water can cut or push through the lowest and most vulnerable points to connect. Thus the main trunk of the river can begin to form even before the river system's tributaries are firmly established.

Earthquakes along fault lines can form the basins or depressed areas of the Earth's crust. Glacial movement can hollow out land and form basins and long valleys. Many glaciers helped to mold river routes during the most recent ice age. Basins can also be formed when meteorites hit the earth.

Rivers can form their own canyons. The Grand Canyon was created by the action of the Colorado River. The water itself can weather away the land; but remember that the water in a river carries abrasive sediments that can scrape and scour the land. Think of how sandpaper or an abrasive masonry blade on a saw can cut through materials. Add to this notion the fact that the heaviest sediments carried by rivers rumble along the bottom of its channel. Thus, owing to the force of gravity, a more downward cutting force is created. The velocity of river flow, the types and sizes of sediments carried, and the resistance of the landscape rocks are all factors in the extensiveness and efficiency of a river's cutting power. Chemical reactions, and freezing and thawing of the water filled rocks and soil pores also aide in weathering the land along a river so it is more easily eroded.

Sediment Loads

There are two basic kinds of sediments: physical and chemical. The most important type of chemical sediment carried by a river (at least one that's not horribly polluted) is salt.

Water falls to Earth as precipitation. Much of this water runs down over the land, eventually forming rivers that fill the seas. As the water runs over and through the land it dissolves the salts out of the rocks and soil. Salts also come from animal wastes such as sweat and urine. The river carries what we call "fresh" or non-salty water, but it does contain these salts in small quantities as it empties into the ocean or sea. In fact rivers are the main vehicles that bring the salts that make the seas salty. As the water in the sea or ocean (or sometimes lake) evaporates over and over, the salt that the rivers continue to bring remains behind; it does not evaporate with the water. As the process has continued to

occur over time, the earth has developed large bodies of salt water. Other minerals besides salt are dissolved by the water that runs into the rivers. Most water is acidic enough to dissolve the more basic minerals that form limestone and other minerals from the soil and rocks. The kinds and quantity of salts and other dissolved minerals that the river brings to the seas/oceans depend greatly on the minerals in the land that its water flows from. Also, people dump soluble chemicals into the river, its contributing waters, or on the land that the water that eventually enters the river flows through. Chemical fertilizers and pesticides are in river water.

The rivers carry weathered and eroded bits and pieces that have been washed from the land as well. I referred to previously as physical sediments, as opposed to chemical. These are usually of soil or rocks but also include pieces from living things such as leaves, sticks, bones or even trash. Rivers have energy in their currents pulled by the force of gravity. Many rivers can even carry large boulders great distances. When something blocks the current's energy, like a dam or a lava flow, sediments build up behind the blockage as the water loses its energy to hold them. When people construct dams on rivers, sediment build-up behind them is often a major problem.

When a river carrying its load of sediments hits the large body of water, it suddenly loses all of its kinetic energy of current flow and drops its sediment load. These dropped sediments are what build up to form deltas at the mouths of rivers. When a river's water runs low or the current loses energy, sediments can be deposited inside of the channel as well. Sandbars are formed in this way. Some of the sediments can also be deposited along the river's banks as the river floods, forming natural levees along the channel. People often try to raise up levees with bags of sand when endangered by river floods. These levees help hold the river within its banks. When the river floods, some of the sediments come out with the river water onto the flood plains. These sediments often contain nutrients and can build up to form fertile river valleys.

Sometimes there is rich soil along a river that has flooded in the past, but the area is too dry now to support vegetation and must be irrigated from the river to grow crops. If the river carries much salt and the area is subject to a lot of evaporation, then the salts can accumulate on the land causing problems for agriculture. This is what happened in the San Joaquin Valley in California.

The Rio Grande

The Rio Grande is the fifth largest river in North America. Its source is several small streams located at almost 12,000 feet in the Southern Rockies of Colorado. From its source in the San Juan Valley, it travels approximately 1888 miles before reaching the Gulf of Mexico, and thereby the Atlantic Ocean. On its southerly route through New Mexico, the Rio Grande courses through the Rio Grande Gorge and White Rock Canyon, then south to the western tip of Texas near El Paso and Juarez, Mexico. The river forms the international border between the state of Texas to the north and Mexican states (west to east towards the Gulf) : Chihuahua, Coahuila, Nueve Leon, and Tamaulipas to the south. The Rio Grande River has cut several large canyons in the Big Bend region of Texas. A true delta has been formed where it enters the Gulf.

The major tributaries on the United States side are the Chama and Rio Puerco of New Mexico entering from the west bank, and the Pecos and Devil's River of Texas from the east. From Mexico (all entering from the west bank) they are the Conchas of Chihuahua, the Salado which begins in Coahuila and enters the Rio Grande through Nuevo Leon, and the Rio San Juan from Nuevo Leon. (Please refer to the second map of the area – attached.)

Geological Formation of the Rio Grande

The formation of the Rio Grande occurs along fault lines in the Rio Grande Rift zone. The Rio Grande Rift zone extends from central Colorado through New Mexico. This is a long valley formed by earthquakes along the faults, and flanked by volcanoes that formed in association with the earthquake faulting. Several long narrow basins probably filled with run-off water; the water would have broken through the lower, weaker basin rims thus joining them together. Geologists have determined that at one time, the Rio Grande ended in a large lake where the city of Las Cruces is today. The river must have broken through the wall of the lake's basin to run its course as it exists today. The Rio Grande has flowed in more or less the same location for almost one million years.

The Formation of Our Aquifer

Under the river is a very deep layer of loose sediments that store water. The valley has been filled up

to its present height by eroded sediments from the higher land around it, mainly the Sandia Mountains. Run-off water filled the porous sediments of the valley, thus forming our aquifer. Most of the residents of the city of Albuquerque get their water supply from this underground aquifer. The river runs higher up above this underground water supply. It is a subject of debate as to whether the ground water table is connected to the underground aquifer. The current thinking seems to lean in the direction that it is not, and that the aquifer contains "fossil water" that is being depleted. Opinions vary on whether the aquifer is being replenished. Some say it is not replenished at all. Others believe it is being replenished, but at a much slower rate than it is being depleted by our use.

The Vegetation

In the mountains of Colorado the river travels through spruce, fir, and aspen forests. This changes to piñon, juniper and sagebrush as the river runs south. The forest along the Rio Grande in central New Mexico is called a "bosque" (Spanish for forest or woods). The dominant tree of the bosque is the Rio Grande Cottonwood . The river commences as it moves south and east, to the dry environment of the Chihuahan Desert. Characteristic shrubs/trees of the Chihuahuan Desert include creosote, mesquite, and palo verde. Near the Gulf, the river enters through a sub-tropical zone, which includes dense thorn (acacia) forests.

Human Use of the River

Irrigation has been in practice along the Rio Grande since primitive times. The Pueblo Indians had irrigation methods when the Spanish arrived in the area. The Spanish improved the irrigation techniques utilized by the Indians with methods they had developed over centuries in Spain. The river's water is still used for irrigation by Pueblo people today. Decendents of the Spanish settlers still use the old irrigation methods learned from their ancestors, especially in some areas of southern Colorado and northern New Mexico. In recent years there have been many disputes concerning ownership and rights between Pueblo, Spanish and Anglo factions in the United States. Mexican allotments and rights have also been at issue. Many compacts and treaties have been made between the states of Colorado, New Mexico, and Texas. Treaties have also been made between the United States and Mexico.

Several dams have been constructed along the Rio Grande and its tributaries. Some of these are used to produce hydroelectric power, others are mainly water reservoirs. Among these are Elephant Butte reservoir on the Rio Grande in New Mexico, The International Amistad Dam located below where the Devil's River of Texas joins the Rio Grande, Falcon Dam on the Conchas in Mexico, Marte Gomez (El Azucar) on the San Juan in Mexico, and Venustiano Carranza (Don Martin) on the Salado in Mexico.

Steamboats were used to go up the Rio Grande from the 1850's until 1874. In 1874 there was a great hurricane which wiped out the vegetation and everything else along the river. The river's banks were moved during the storm and navigation by steamboats was stopped due to increased erosion and sandbars.

International Concerns

One international concern has been a question of which country gets how much of the river's water for its use. When the river's channel position changed, what's known as the Chamizal region (between El Paso and Juarez) was transferred to the left bank. It was then decided that the Chamizal would belong to Mexico. The river's channel moves not only due to the effects of hurricanes, but also slowly over time. As the river traverses its course, the channel naturally meanders to and fro. Understandably, the United States and Mexican governments have had to spend a lot of time and money on boundary adjustments.

Saline water tends to run out from the Lower San Juan irrigation district and contaminate the Rio Grande river. So the U.S. and Mexico worked together to construct a drainage canal on the Mexican side of the delta region. The canal is a extension of the Morillo drain and prevents the salty water from entering the Rio Grande.

Environmental Issues

The river water has been contaminated with substances that are toxic to living things. Some people still use untreated water from the river for drinking and cooking. Many people believe that the Rio

Grande is too unclean to wade, swim or recreate in. Others, including some outspoken members of Indian pueblos along the river, fear that using the river water for irrigating crops, may be making them unhealthy for human or animal consumption. Some people may be concerned about the health of their livestock and other animals that drink the water.

The cottonwood trees look majestic when one views the bosque along the middle Rio Grande. But the Rio Grande cottonwood is a short lived tree, and studies have shown that new trees are not surviving to the sapling stage. Two main factors are to blame. One factor is the lack of seasonal flooding and the lowered water table. The release of the "cotton" covered seeds occurs at the same time the spring floods used to occur along this section of the river. The seeds seem to need this extra flood water to get a good start. Their roots must keep up with the lowering water table which continues to fall. The sapling stage is when a tree's roots make it down to the lowest level of the water table. The second main factor may be that the water table has been lowered as more water has been taken from it and from the river which feeds it, making it more difficult for the tree roots to reach it.

The bosque forest ecosystem has further been threatened by the invasion of non-native plants. The Tamarisk tree is said to be the most troublesome. The Russian Olive tree is another very prevalent exotic invader in the bosque. The introduction of non-native animals is also of issue.

Many species of plants and animals that used to be prevalent along or in the river are no longer found there or are considered threatened. About half of the species of fish that once lived in the river are no longer found there. Disturbance by dams, urban encroachment, pollution, and the introduction of non-natives are relevant factors.

Implementation

This curriculum is designed to span a fifteen day period.

Days 1-5: The basics of general river formation, components and mechanics will be taught.
Days 6-10: River research, drawings and presentations in groups or pairs.
Days 11-15: Material specific to the Rio Grande river system will be covered in an effort to promote "teaching deeply rooted in place" (Lamadrid).

In addition, there is one pre-lesson at the beginning, and several follow-up or optional lessons and topics are included at the end.

State standards addressed by the lessons are noted herein by Content Standard number followed by Benchmark letter (a written out version of all standards referred to herein follow at the end of this section).

Pre-lesson

Objective: To prepare the students to understand later information in this unit (on day four), and to refer to in the follow-up lessons regarding the Gulf of Mexico and Oceans.

Fill a 300ml beaker with hot water. Stir in as much salt as will dissolve. Label the beaker by class period and set it up somewhere warm, dry, and where it won't be disturbed. Ask the students if they knew that water could dissolve salt or that the Earth's seas and oceans are getting saltier and saltier? Ask them how they think the salt gets in the sea, and why the seas and oceans are getting saltier (wait for responses to each question). Tell them that the rivers bring dissolved salts to the seas and oceans. That the water from the seas and oceans is evaporated over and over but the salt does *not* evaporate; it is left behind. Tell them that they will observe the beakers in a couple of weeks and see that this is true.

Materials:
One 300ml beaker per class
Salt
Hot water
Spoon or stirring rod
Wax pencil or masking tape and pen to label with

State Standard: 1.B.

Note: The pre-lesson fits in well after a lesson on the percents of the earth's surface that is covered by land and water. Some discussion beforehand pertaining to fresh and salt water is also helpful.

Lessons:

Day One – Objective: Students will be introduced to "rivers," and gravity as the force that moves rivers by use of a world map and discussion.

The teacher asks the students to name rivers that they know and then points them out and traces their main courses on the map in front of the class (a review of continents and oceans/seas can easily be fit in).

After tracing each river the teacher asks, "And in which direction does the _____ river flow? " After following this procedure for several major rivers, she/he asks the at first baffling question, "In which direction do **all** rivers flow?". After several responses from the students, if no one guesses/knows the right answer, the teacher admonishes, "All rivers flow **down**"! Then the teacher might ask "And **why** do they flow down?" or "What force makes them flow down?" When someone gets the answer (gravity), I often ask some reinforcement/review type questions such as "In what direction does gravity (at least here on Earth) always pull things?" or "What place in the earth does gravity pull everything towards?" I usually go for a globe at this point to clarify that gravity on the earth pulls **everything** that has any mass or weight at all towards the center of the earth, and that for water in rivers, that means **down**! A simple demonstration of the downward flow of water, such as just putting some on the table and then tilting the table to make it flow down, can easily be inserted here. Discuss the force of gravity as something in nature that does not change over time. Compare it to other things that do change, for example the topography of the land, courses of rivers, populations of organisms, life stages of stars, etc…

- Show the short introductory film, *River, Where Do You Come From* which is available through the APS film library (or show another film that is suitable).

Materials
Large classroom world map
Water and table (optional)
River, Where Do You Come From or other short introductory video

State Standards: 1.A., 1.B., and 4.A.

Day Two – Objective: Students will learn about what rivers are, their component parts, river mechanics and how they begin and end.

Teacher writes/draws Notes on Rivers (see figure one) all across a long blackboard. She/he starts off by drawing a mountainside with precipitation coming down on it.

She/he asks the question, "What are four things that can happen to precipitation after it reaches the ground?" and writes the word "precipitation" above the mountainside with four lines out from it to fill in. The answers are: sink into the ground, run off over the ground, evaporate, and go to living things. Then ask, "and which one of these cause rivers to form?" Go on to draw a river system with run-off precipitation first becoming gullies and rills, then these joining to form streams which come together to make a river. Label all the river components along the way, including the part nearer the source as the "younger river" and the "older river" farther down. As I get to the part where the older river starts to "meander" I like to act out meandering, and the kids love it. I pretend that I'm a student "meandering" up to the pencil sharpener, taking a very indirect route, being distracted and causing mischief along the way. When I talk about the sediment loads of rivers and how the river's current has energy to carry the load, I act out this as well. I start on one end of the room as a river rolling my arms as if carrying sediments. I run along with my load, happily, and then as I run up against the ocean I utter a loud "Whoa" sound as I drop my sediment load. The students finish copying the drawing (which often goes over onto the back of their papers), and labeling it. Then the teacher gives them the vocabulary words relevant to the day's lesson. The teacher can either continue to work with the students by going over the words and coming up with definitions for them to copy, or have them look up the words in their text book glossaries.

- Students are to study their notes/complete vocabulary for homework.

Materials - teacher: A long Chalkboard, chalk and eraser Figure One and River Notes Vocabulary

(attached)

Materials – student:
Notebooks with paper
pencils

State Standards: 1.A., 2.C., 12.C., and 12.G.

Day Three – Objective: Students will demonstrate knowledge of river system components and how gravity affects river flow, by taking a quiz.

Review for and take a quiz over the material covered. The teacher leaves the river drawing up on the board but with all the labels or other words erased. She/he reviews the names of the river components with the students. The vocabulary words are written in scrambled order and without definitions, on the board. After reviewing, the teacher tells the students to head and title their papers and number 1-10 skipping lines. She/he asks ten questions either pointing to parts of the drawing for them to name or giving definitions and having them write the word from the board that matches. I ask two extra credit questions at the end: "What direction do **all** rivers flow?" and, "What is the name of the force that causes rivers to flow?"

Materials – teacher:
Long chalkboard and eraser

Materials – student:
Paper and pencil

State Standards: 1.A., and 12.G.

Day Four – Objective: Students will learn about river water erosion and deposition of sediments through reading, discussing, and a slide-show presentation of the Grand Canyon.

Read and discuss about water erosion and deposition of sediments (we use Glenco *Earth Science*).

- Tell the students that it's not just the *water* that cuts through and erodes the land that the water is carrying sediment, much of which is often sand (show them a piece of sandpaper and demonstrate/discuss how it can cut through things). Explain to them that rivers can carry rough gravel and even large boulders. The boulders, being heavier, rumble along the bottom of the channel cutting it deeper.

- Remind the students that water can dissolve salt (refer to the beaker with salt water solution). Tell them that as the water that makes up or will eventually make up the river runs over the land, it dissolves the salts out of the rocks and soil and carries them to the sea or ocean. The salt is an example of a *chemical* sediment carried by the river.

- Show slides of the Grande Canyon and discuss how the river has shaped the land.

Materials – teacher: A classroom set of Earth Science textbooks
Sandpaper and something to sand through
Beaker with salt water solution (previous demo)
Slides of the Grand Canyon (Available through ATI office)
Slide Projector and a wall or screen to project onto

State Standards: 1.B., 4.E., 12.A., and 12.C.

Day Five – Objective: Students will learn about aquifer formation and function by utilizing an illustrated discussion and a demonstration activity.

Discuss, illustrate on board, show overheads of, read about in textbooks, or otherwise cover aquifer formation and function.

-Demonstrate the amounts of water that different loose sediments can hold. Fill three different beakers with equal volumes of coarse gravel, fine gravel, and sand. Use a "to deliver" graduated cylinder to find out how much water each sediment type will hold. Draw a chart on the board for students to copy

and fill in the amounts of water held by each.

-Introduce the next day's lesson by showing the students a list of names of rivers on the chalkboard or overhead. Tell them they will be working in partners/ groups of whatever number you think will work well, and that each set of partners/group will need to choose a river on which to do a report.

Materials – teacher
Chalkboard and chalk
Overhead transparencies and projector (optional)
Three large (300-600ml) beakers per class
One "to deliver" graduated cylinder (200-500ml)
Coarse gravel, fine gravel, and sand (enough to do the demonstration in each class)

Materials – student
Notebooks with paper
Pencil

State Standards: 4.C., 4.D. and 12.B.

Days Six – Eight - Objective: The students will apply knowledge learned and further explore river systems by conducting research on and drawing a model of a river system of their choice.

Two to three days in the school library must be pre-arranged The teacher prepares ahead of time by listing the criteria the students are to include in their reports in marker on a large piece of poster board. Sets of water-based markers and one large piece of light colored butcher paper will also be needed.

The teacher takes the students to the library and they sit with their work groups. She/he tells them that they will be presenting oral reports up in front of the room and will need to know the things about their river that are listed on the poster board that she/he shows while going over each and making suggestions as to where to find the information. Then the teacher holds up one of the big pieces of butcher paper and tells them that they will also need to make a large drawing of their river using the atlases or other sources. Remind them that they will be holding the drawing up for everyone to see (so they will need to draw in pencil first, but then go over their work with a marker), and should write the name of their river in big dark letters at the top or bottom of their drawing.

Some of the information I have them find: The continent the river is on, the direction (cardinal) of flow, the locations of its source and mouth, the body of water it empties into, major tributaries, kind/amount of sediment load, and any dams along its course. I also ask them to include something else that they consider interesting about their river.

Materials – teacher
Large poster board and marker
Sets of water-based markers for students to use
Large pieces of light colored butcher paper (one per group of students and a few extras)

Materials – library
Encyclopedias, river books (optional), and world atlases.
Materials – student
Notebooks with paper
Pencils

State Standards: 1.A., and 2.C.

Days Nine and Ten – Objective: The students will demonstrate and impart knowledge of a particular river system, utilizing research and a model drawing.

Fifteen to Twenty minutes may be allotted for students to polish up their river drawings and notes. Students stand in front of the room with their groups, hold up their drawings, and give their reports to the class. Each presenter begins by saying, "The name of our river is the _____ river" and pointing to it/tracing its course on the world map. They then can look at the poster board with the information or can be coached by the teacher as they continue their reports. When a report is finished, a member of the group should ask, " Are there any questions?" At that time students in the class may

raise their hands to be called on. The teacher also may ask questions and gives each group a grade as they finish.

Materials – student
River drawing and notes (from previous lesson)

State Standards: 1.A., and 2.C.

Day Eleven – The students will focus on the Rio Grande, as the river of interest in our area through guided discussion and a slide-show presentation of the Rio Grande.

Discuss the Rio Grande and look at the map, applying and reviewing what has been previously learned. Focus on particulars of interest such as dams along it or its tributaries, the fact that it is an international border, irrigation ditches, etc…
-View some slides of the Rio Grande and discuss

Materials - teacher
World Map or other
Large classroom map showing the Rio Grande
Slides of the Rio Grande (Available from ATI office)

State Standards: 4.E., 11.F. and 12.B.

Day Twelve – Objective: Students will help construct models of the Rio Grande from three different time periods. Students will learn about change over time.

Teacher Preparation: Bring in a gray or brown blanket, some long strips of blue cloth to represent the river, some shorter pieces of blue cloth to represent the pre-river water-filled basins, and other prepared components from the Bosque Education Guide's models of the old and new versions of the Rio Grande.

Begin by laying out the blanket on the floor, and asking some of the students for their backpacks. Place the backpacks under the east end of the blanket, to represent the uplifting of the Sandia Mountains. Place lower objects under the west end of the blanket to represent the WestSide Escarpment or volcanoes. See if the students can tell you what the elevated areas represent and what's located in between them. Tell the students that just like the mountains and volcanoes, the river wasn't always there. Put down the basin shaped pieces of blue cloth and tell the students that before the river formed, there was a series of basins caused by faulting (earthquakes), and that they became filled with water as the precipitation ran off over the higher land to the lowest areas - the basins. Ask them what they think happened as more and more water ran off from the higher land. Then replace the basin pieces with the long blue strip of cloth which represents the river. Make sure that as you lay it down you form it into several large meanders to represent what's referred to as the "old river model" in the *Bosque Education Guide*. *You may or may not want to extend to using all the animal cards - if you choose to include them, you will need to allow an extra day for this activity.* Go on to the "new river model" by telling the students that the Rio Grande was very different in lots of ways one hundred years ago than it is today. Ask them to come up with some ways that it has changed and discuss. Straighten out the river, add the irrigation/drainage ditches, jetty-jacks, etc.., to make the "new river" as explained in the *Bosque Guide*. Again, the animal cards are optional. If you teach Life Science or Biology you'll probably want to include them. Directions for making the old river (rio viejo) and new river (rio nuevo) models are on pages 35-38 of the *Bosque Education Guide*.

Materials – teacher
Bosque Education Guide and model components prepared from it.
Large gray or brown blanket, long strip/s of blue cloth approximately eight inches wide (for river), and shorter pieces of blue cloth with rounded ends (for basins)
Backpacks, books, or other objects to form the mountains/volcanoes
Brown or green cloth to cut squares/rectangles for farm fields
Blue ribbons for ditches/drains
Brown ribbon for levees/jetty jacks

State Standards: 1.A., 1.B., 2.C. 4.A., 4.E., 4.F., 11.E., 11.F., 11.H., 12.B., 12.C., 12.G. and 16.B.

Day Thirteen – Students will review change of the Rio Grande river system over time through directed discussion. They will also become familiar with current/local issues regarding the Rio Grande by watching a video.

Review over yesterday's lesson. Ask the students to write the following in their notebooks: " Five ways in which the Rio Grande is different now, from one hundred years ago." They then list the five differences (or more for extra credit).

-Watch *One River, Many Voices* video

Materials – teacher
One River, Many Voices video

Materials – student
Notebooks with paper
Pencils

State Standards: 4.A., 4.E., 11.F. and 11.H.

Day Fourteen – Objective: The students will work together to explore and agree on a solution to a problem situation related to the Rio Grande.

Divide the students into groups of three to five students each. Hand out one Rio Grande Problem solving activity card to each group. Tell the students that each group is to work together to decide how they would solve the problem situation that is described to them on their card. The teacher can allot each group a certain amount of money to spend on solving their problem. She/he can list categories for expenditures up on the board. Here are some suggested categories: research, education, compensation, lawyers, and materials. The students can also come up with their own categories more specific to the problems they were given.

Materials - teacher
Problem Solving Activity Cards (attached)
Chalkboard and chalk

Materials – students
Paper and pencil, at least one per group

State Standards: 12.B., 14.B., 15.B., 16.A., 16.B., and 16.C.

Day Fifteen – Objective: The students will demonstrate their familiarity with current/local issues related to the Rio Grande, and critical thinking skills, by giving presentations and discussion.

The student groups present their problems and solutions. Each group presentation is followed by a class discussion directed by the teacher. The teacher tells the class more about each problem situation, as per the "Problem Solving Activity Card – Teacher Information" (attached), or by relying on personal knowledge. The teacher gives each group a grade based on their presentation. Extra points can be given to those students who participate in the discussions.

Materials – teacher
"Problem Solving Activity Card – Teacher Information" (attached)
Chalkboard and chalk
Grade book

Materials – student
Group notes for presentations

State Standards: 12.B., 14.B., 15.B., 16.A., 16.B., and 16.C.

Follow-up/Optional Lessons, Activities and Topics

The unit may be followed by lessons centered on the topic of Oceans -

Beginning with the Gulf of Mexico through which the Rio Grande enters the Atlantic Ocean, and

going on to oceans in general makes the transition smooth. The Gulf-ocean lesson can be nicely covered or enhanced by a fieldtrip to the Albuquerque Aquarium (see below).

The Water Cycle activity from page 85-96 of the *Bosque Education Guide* - This activity demonstrates the connections between the river, aquifer, ocean, precipitation, evaporation, residential/industrial use of water, etc...(State Standard 12.G.), in a way that's fun and easy for students to learn. It does require advance preparation however.

A fieldtrip to an irrigation ditch in conjunction with showing the video *Rio Grande, New Mexico's Treasure* - The video and guest speakers are available by contacting the Middle Rio Grande Conservancy District office in Albuquerque (505-247-0234).

A fieldtrip to the Rio Grande Nature Center (505-344-0274) - perhaps in conjunction with one to another area of the bosque or to the Albuquerque Aquarium (505-764-6200).

A guest speaker from the Rio Grande Restoration Project (505-266-8609) - Personnel from this project may be able to help arrange a fieldtrip to the Tingley Beach area of Albuquerque where a restoration project is currently in progress.

Complete List of State Science Standards (Grades 5-8) Referred to in This Unit:

Content Standard One: UNIFYING CONCEPTS AND PROCESSES
STUDENTS WILL UNDERSTAND SCIENCE CONCEPTS OF ORDER AND ORGANIZATION
Benchmark A: Apply information about the predictability and organization of the universe and its subsystems.
Benchmark B: Apply prediction to scientific problems and events.

Content Standard Two: UNIFYING CONCEPTS AND PROCESSES
STUDENTS WILL USE EVIDENCE, MODELS, AND EXPLATIONS TO EXPLORE THE PHYSICAL WORLD
Benchmark C: Design and develop models.

Content Standard Four: UNIFYING CONCEPTS AND PROCESSES
STUDENTS WILL UNDERSTAND THE PHYSICAL WORLD THROUGH THE CONCEPTS OF CHANGE, EQUILIBRIUM, AND MEASUREMENT
Benchmark A: Illustrate that constancy and change are properties of objects and processes.
Benchmark D: Employ mathematics to quantify properties of objects and phenomena.
Benchmark E: Relate the contributions of external and internal forces to change in the form and function of objects, organisms, and natural systems.
Benchmark F: Examine the impact humans have had on other species and natural systems over time.

Content Standard Eleven: LIFE SCIENCE
STUDENTS WILL KNOW AND UNDERSTAND THE SYNERGY AMONG ORGANISMS AND THE ENVIRONMENTS OF ORGANISMS
Benchmark E: Categorize organisms based on the function they serve within their ecosystem.
Benchmark F: Examine the impact humans have had on other species and natural systems over time.
Benchmark H: Analyze consumption of nonrenewable resources based on population factors (birthrate, death rate, and density).

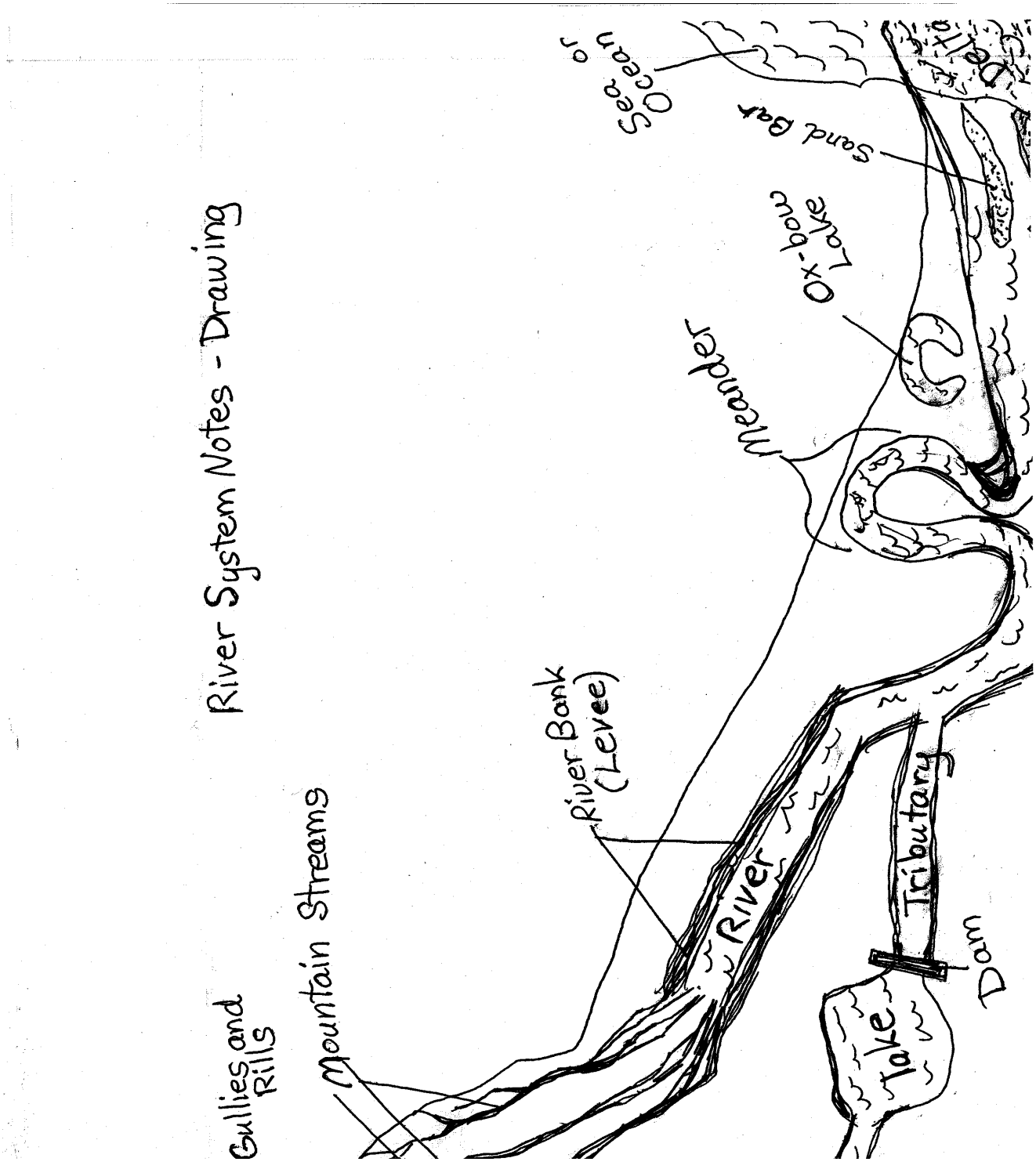
Content Standard Twelve: EARTH AND SPACE SCIENCE
Students will know and uNDerstand properties of earth science
Benchmark A: Explain how Earth's materials can be transformed from one state to another.
Benchmark B: Experiment with the uses of Earth's materials as resources.
Benchmark C: Model natural processes that shape the Earth's surface.
Benchmark G: Describe the interaction between the Earth's lithosphere, hydrosphere, atmosphere, and biosphere.

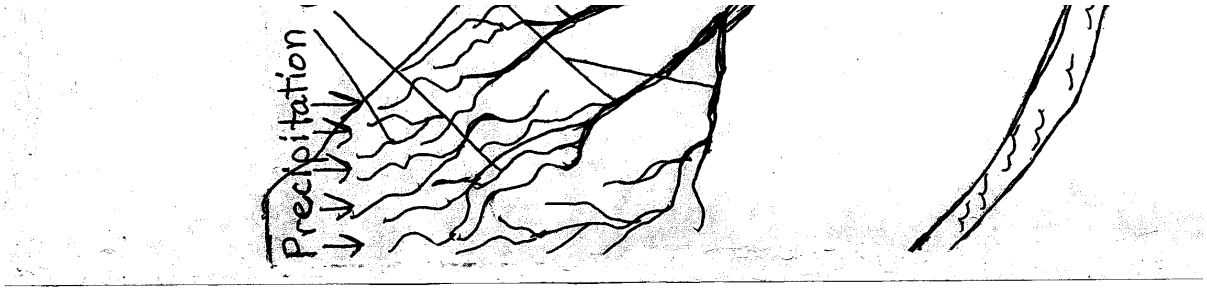
Content Standard Fourteen: TECHNOLOGY AND THE HISTORY OF SCIENCE
STUDENTS WILL KNOW AND UNDERSTAND THE DIFFERENCES BETWEEN THE INTERACTIONS OF SCIENCE AND TECHNOLOGY
Benchmark B: Demonstrate trade-offs in safety, cost, efficiency, and appearance related to technological solutions provided through science.

Content Standard Fifteen: Technology and the history of science

students will know and understand the impact between science and technology in society
benchmark B: Demonstrate how the direction for scientific investigations is related to social issues and challenges.

Content Standard Sixteen: SCIENCE IN PERSONAL, SOCIAL, AND ENVIRONMENTAL PERSPECTIVES
STUDENTS WILL KNOW AND UNDERSTAND THE RELATIONSHIP BETWEEN NATURAL HAZARDS AND ENVIRONMENTAL RISKS FOR ORGANISMS.
Benchmark A: Analyze environmental risks for personal and social costs.
Benchmark B: Determine options for reducing and eliminating environmental risks and for coping with natural catastrophic events.
Benchmark C: Predict the human and financial cost of slow natural events such as drought and rapid natural events such as earthquakes.





River System Notes Vocabulary *

Watershed or **River Basin** (*Span.*=La Cuencia)**:** The whole area of land drained by the river and its tributaries
River Channel: The hollowed out area of land in which the river flows
River Banks: The sides of the river channel
Riverbed: The bottom of the river channel
Levee (natural)**:** Areas built up by flooding waters that drop their sediments along riverbanks. (Note: *Artificial* levees are built up by people, often using sandbags for river flood control.)

***** These are the only vocabulary words I usually use for this part of the lesson. The other words they are expected to know are self-explanatory from the drawing.

Rio Grande Problem Solving Activity Cards

A.

Problem: Silt and other sediments have been building up behind a dam built on the Rio Grande. This also caused the water level behind the dam to rise more than it normally would, over the build-up. The silt and water overflowed the banks of the river and caused a small town to be flooded and covered with many feet of silt and other sediments.

B.

Problem: The Rio Grande no longer reaches the Gulf of Mexico. There is not enough water. Much of the water has been diverted to irrigation ditches or is held in reservoirs (lakes). The water is also used by city residents, public works, and industries. There has been a drought in Texas and the states of northern Mexico through which the river flows. The area where the Rio Grande meets the Gulf is home to a multi-million dollar shrimping industry. The shrimp and many species of fish require the brackish (mixture of fresh and salt) water to complete their life cycles.

Rio Grande Problem Solving Activity Cards

C.

Problem: The Rio Grande cottonwood trees have disappeared from along many stretches of the river already. If we don't do something to help them produce young trees that survive to the sapling stage in a suitable environment, they will probably be gone soon **here** as well. The young seedlings require a flooded area where they won't be washed away, to survive. The river is now kept in its channel and flooding is prevented. They also must be able to get their roots down to the water table as the land dries after a flood. The ground water table has been lowered by people pumping the water out for residential, public and industrial use; so this is another problem for the cottonwoods. Several non-native trees and shrubs (most notably Salt Cedar and Russian Olive) have taken over the areas where young cottonwoods would have grown if conditions were right.

D.

Problem: The Rio Grande is the border between the United States and Mexico. But the river's channel keeps changing! This leads to much confusion and arguments between the two countries. It is hard to know which land belongs to the United States and which to Mexico. Residents aren't sure whether they are Mexican or United States citizens in many of these areas. In one particular area, the river has continued to move towards the south, and has recently moved **more** in this direction. Some of the questions that are under consideration are; Do the people in this area now become US citizens? Do they have to move to the other side of the border because the land now belongs to the United States? Do we wait and see if the river moves north again before we decide?

E.

Problem: The aquifer which a large city along the river pumps its water from is being depleted. The aquifer ***had*** been thought to be inexhaustible, so large industries that use lots of water have been allowed to locate here as well. The city must quit taking so much water from the aquifer and/or find another source of water. The quality of the water from some of the city wells is not as good as it used to be. Officials fear that if they do not do something to solve this problem now, that some wells will soon go dry altogether.

F.

Problem: A type of small river fish native to the Rio Grande is endangered and may become extinct. The dams along the river prevent the fish from continuing to travel the river as it normally would. Also, the river dries up all together below some of the dams in late summer. This lack of water also threatens the fish.

Rio Grande River – Problem Solving Activity Cards

G.

Problem: Toxic chemical pollution in the Rio Grande is causing fatal birth defects in villages along the river. The villages that are affected are located on the Mexican side of the river, downstream from U.S. industries that cause the pollution. The Mexican government has allowed the industries to locate where they are. The industry owners ***chose*** to operate in Mexico because the Mexican government allows the pollution, whereas the United States does not.

H.

Problem: The Rio Grande's channel keeps changing within a city's limits, causing destruction and wrecking havoc. The river is higher than the city in some places so when it floods these areas are hit hard.

Rio Grande Problem Solving Activity Cards

I.

Problem: All of the trees, bushes, and brush along the Rio Grande bosque have been taken by local villagers to use as firewood to heat and cook. The Plaza Vieja of the village has recently flooded badly several times. The increased flooding is believed to be caused by the removal of the vegetation along the river. The trees, bushes, and brush used to help keep the river in its banks by holding the ground with its roots, and by acting as a barrier to water flow during flood. Now the river erodes and overflows its banks more easily.

J.

Problem: The Rio Grande is filled with mud and other sediments.

They are clogging the channel and preventing water flow. Most people believe that overgrazing of the surrounding lands is mostly to blame. The overgrazing has removed much of the vegetation that used to keep the land from washing away into the river. The soil washes away with each rain storm.

K.

Problem: Two cities adjoin each other on either side of the U.S.- Mexican border. Partially treated sewage from the city on the U.S. side crosses over to the city on the Mexican side in an open ditch. The sewage from the Mexican city is also emptied into the ditch, which drains into the Rio Grande.

L.

Problem: The drinking, possession or selling of alcoholic beverages has been made illegal in the United States of America. Alcohol continues to enter the country illegally, especially from the Chamisal region of Chihuahua, Mexico. A teenager known as the "Chamisal Kid" and others, have been bootlegging supplies of alcohol across the river border.

Teacher Information for the Rio Grande Problem Solving Activity Cards

CARD – A

This scenario is based on the San Marcial story. San Marcial was a village along the Rio Grande river near Elephant Butte dam in southern New Mexico. The river broke through its banks behind the dam, twice flooding the town and covering it in silt. The silt had built up behind the dam causing the water level to rise on top of it and the water broke through the river bank allowing the silt to follow. The town of San Marcial was in its path. The first time this happened, the people of the town rebuilt, but when it happened for a second time, they gave up and relocated across the river and elsewhere. The Red Cross helped them out.

CARD – B

Since February of this year(2001), the Rio Grande river dries up before reaching the Gulf of Mexico. The last time that this is said to have happened was in the early 1950s, also during a drought (Armstrong 10 - 11).

CARD – C

This is the actual situation regarding the bosque in the Albuquerque area and for most of the bosque through central New Mexico. Efforts are being made to save the Rio Grande cottonwoods through lowering the riverbank to allow for flooding in some areas. Cottonwood saplings are being raised on farms and "pole-planted" so that their roots reach the water table. There are also experimental efforts to remove non-native Russian Olive and Salt Cedar(Tamarisk) trees which have taken over some of the areas previously covered by cottonwoods.

CARD – D

This was the situation in the Chamisal, a region of land between the states of Texas(U.S.) and Chihuahua(Mex.). The problem was resolved by Presidents Kenedy (followed by Johnson) of the United States and Mateos of Mexico. They agreed on a permanent boundary and river channel. A concrete ditch was constructed to keep the river in place. Many families were paid by the U.S. government to relocate and would remain United States citizens. On the Mexican side, families were also told to move so that the Mexican government could build a public park to commemorate the friendship between the two countries. The Mexicans were not paid to relocate.

CARD – E

The "large city" is Albuquerque in the present day. There have been many proposed solutions to the diminishing water supply from our aquifer. Residents have been asked to conserve home water use. Watering of outdoor plants is only permitted on certain days/times. People are encouraged to xeroscape their yards with plants that are drought tolerant. A massive campaign has been launched to increase people’s awareness of the water situation/problem. Some years back the

City of Albuquerque purchased San Juan River water. The San Juan is a tributary of the Colorado River. This purchased water is piped across the Continental Divide and into the Chama River, which flows into the Rio Grande. City officials plan to remove the amount of water purchased from the Rio Grande and process it to supplement the water that we use from the aquifer. Another idea is for the city to further purify and reuse the water effused from the Waste Water Treatment Plant.

CARD –F

The fish is the Silvery Minnow of the Rio Grande. At least two other similar fish have already become extinct. The Albuquerque Aquarium and the Zoological Park are working together to raise/breed large numbers of the minnows in captivity. The plan is to release them into the wild at some future time and hopefully they will survive. Efforts are also being made to figure out a way to allow the minnow to pass through the dams. Water may be released from lake reservoirs to keep areas of the river downstream from the dams from drying out in areas where the minnow is known to live. Other small fish that used to be in the Rio Grande have already become extinct.

CARD – G

This card refers to a birth defect which causes a baby to be born with a hole in its skull. According to the Medical Investigator’s office, this defect has been blamed on toxic industrial chemicals in water used for human consumption, and is found in small Mexican villages along the Rio Grande, downstream from U.S. industries.

CARD –H

This was the situation in the Albuquerque area before the Middle Rio Grande Conservancy District solved the problem. The Conservancy District drained flooded lands and constructed dams to store and regulate the flow of the river’s water. The MRGCD also constructed an elaborate irrigation/drainage canals that flow out from the river in some places and enter back into it in others.

CARD – I

The city may or may not have been Albuquerque. It occurred in the early days of settlement along the Rio Grande river.

CARD – J

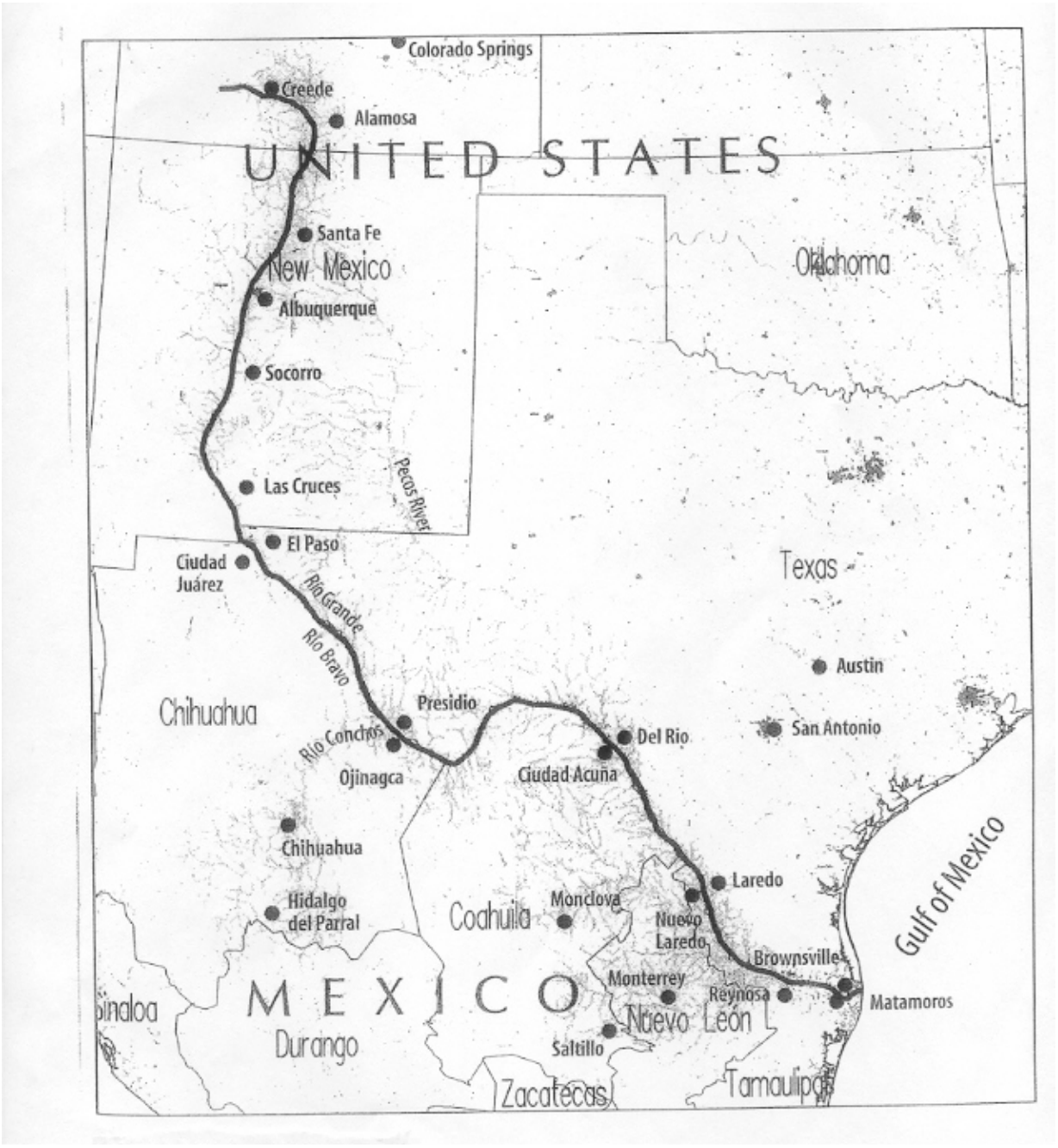
The river filled up with mud in the years prior to the activities of the Middle Rio Grande Conservancy District. Most people believe that extensive overgrazing by too many herds of cattle was the biggest reason to blame.

CARD –K

A similar boundary related problem situation occurred between the border sister cities of Douglas, Arizona (U.S.) and Agua Prieta, Sonora (Mex.). The actual situation did not involve the sewage being discharged into a river. This scenario is largely hypothetical. The problem between the actual cities was resolved with the help of the International Boundary Commission. The two cities worked together to construct one adequate sewage treatment facility for joint use.

CARD – L

During the U.S. Prohibition, there actually was a famous teenage bootlegger in the Chamisal region of Mexico, known as the "Chamisal Kid" (Trillo).



Source: Smithsonian Institute. 2000

Source: International Boundary and Water Commission. 2001

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