17. Working Water

Agriculture Along the River

Description: With a concentration on the agricultural aspect of the Middle Rio Grande Valley, students focus on creating an irrigation system on the "River of Change" model, expanding on and exploring human influence on the Rio Grande created in the Rio Manso river model.

Objectives: Students will understand:

- one of the main human uses of the river, agriculture;
- the physical characteristics and layout of an agricultural district;
- science and engineering elements in an irrigation system; and
- impacts of agricultural system on the bosque ecosystem.

Phenomenon: Irrigation water flows from the river through ditches to the fields.

Lesson Questions:

- *How does irrigation water work?*
- *How does it get here, and where does it go?*

17. Working Water

Grades: 2–12

Time: initial materials preparation about 30 minutes; another hour to assemble the river, learning where each component goes and how it affects the river system

Subjects: science, social studies

Terms / Términos:

Acequia	*Acequia*
Check	*Control*
Dam	*Presa*
Ditch	*Foso o zanja*
Gaging stations	*Estaciones de medición*
High-line canal	*Canal de alta línea*
Irrigation district	*Distrito de riego*
Lateral	*Lateral*
Real-time data	*Datos en tiempo real*
Riverside drain	*Drenaje junto al río*
Suspended sediments	*Sedimentos en suspensión*
Turnout	*Desvios*

New Mexico STEM Ready! / Next Generation Science Standards

NGSS DCIs and New Mexico State Performance Expectations

5.ESS3.C Human Impacts on Earth Systems

5.PS2.B Motion & Stability: Forces & Interactions

MS.ESS 3.C (MS-ESS3-3 NM) Human Impacts on Earth Systems

MS.ETS2.B (MS-ESS3-3 NM) Influence of Engineering, Technology & Science on Society & the Natural World

NGSS CCCs

Cause & Effect: Mechanism & Explanation; Systems & System Models

NGSS SEPs

Asking Questions & Defining Problems; Developing & Using Models; Constructing Explanations & Designing Solutions*; Obtaining, Evaluating & Communicating Information*

Materials:

- River model set up as Rio Manso. It helps if there is something underneath the model so students can see a slope from foothills to river, and imagine the force of gravity helping the irrigation system work.
- One copy of Working Water student cards
- Scissors
- Envelopes or sandwich bags to hold the pieces and information cards
- Colored pencils or markers (optional)
- Material (listed by color) for various waterways:
  - Rectangular piece of paper or felt for the diversion/utility dam; cut at least the width of the river
  - Two long strips of light-blue fabric or ribbon approximately the length of the river for the high-line canal (these are in addition to the strips or flagging used in "Changing River" to represent the drains alongside the levees described below)
  - Eight shorter strips of blue fabric or yarn for the laterals, acequias, and ditches; they should be about one-fourth the length of the river
  - 20 or so circles, about an inch in diameter, for turnouts
  - Trapezoids or rectangles to represent checks
  - Two long thin strips of fabric the length of the river for the river-side or interior drains (or use the Rio Manso drains)
  - Six to eight small cylinders, cups or film canisters for the gaging stations
  - Distinctive yarn to outline the conservancy district's boundaries

Background:

Irrigation districts, or conservancy districts, are groups of farmers who have come together and pooled their resources so as to reduce the time, money and effort required for profitable irrigation-based agriculture. Instead of trying to maintain their own individual ditches and diversion structures and manage their own allotments of water, farmers can form an irrigation district that is responsible for all the aspects of irrigation for an agriculture community. These aspects can include ditch maintenance, water delivery scheduling, system improvements, water managing and possible legal actions, to name a few. Typically, taxes and water delivery fees are collected by the irrigation district for these uses. The benefit of an irrigation district is obvious in a place like the Middle Rio Grande Valley. It is much more efficient for 10,000 individual farmers to work together, as they do here, than for each one to work on his or her own.

The major purpose of an irrigation district is to efficiently deliver water from a given river to farmers who have water rights on that river. Irrigation districts use gravity as the key force to move water efficiently. Gravity is the force that one body, the earth, has on a second body, in this case water. The important idea to remember here is that the force of gravity on earth pulls all objects towards the center of the earth, and thus always pulls downhill. This being the case, irrigation districts can use gravity to their advantage to convey the water to the desired fields. **Diversion dams**, the structures that divert water from the river, are located at the highest point in the district. Diversion dams feed high-line canals, which are the major artery of the irrigation district. **High-line canals** tend to follow the highest points in the valley that are possible while the water is still flowing downhill, so that as much land as possible can receive water. **Laterals, ditches** and **acequias** branch off the high-line canals and run downhill towards the farmer's fields. Often a farmer will have a personal ditch that delivers water to particular fields the farmer irrigates. These also move water via gravity. In general, all the ditches in an irrigation district drop in elevation more slowly than the river from which the water came. This way, water that is not used by the farmers can return to the river downstream via the force that originally removed the water.

Sometimes the level of water at a particular point in a ditch is too low to feed a turnout to an offshoot ditch. A **turnout** is basically a pipe coming off a ditch which can be open and closed as is needed. This problem is easily solved by the use of a **check** structure. A check is a miniature dam that can be put in place and removed as needed. By placing a check in a ditch that would otherwise have a water level too low to feed a turnout, the level of water above the check will rise and eventually force water into the desired turnout. This is a major way the irrigation engineers can manipulate gravity.

The lowest part of the system are the drains. These lower the ground-water level so that irrigation water will move through the soil and away from plants' roots. An analogy is a house plant in a pot. There is always a hole in the bottom of the pot for excess water to drain out so the roots don't get saturated. Drains in irrigated lands flow into the river, returning water to the Rio Grande.

Irrigated agriculture has been going on in the Middle Rio Grande Valley since the 1600s. The Middle Rio Grande Conservancy District (MRGCD) was formed in 1923 combining more than 70 individual community acequias, or small irrigation districts. An entirely new irrigation network was created to better irrigate the land in the Middle Rio Grande Valley. The MRGCD has four diversion dams (Cochiti, Angostura, Isleta and San Acacia) and more than 1,200 miles (1,920 km) of ditches. The district encompasses about 300,000 acres (120,000 ha) of total area. The MRGCD has rights to about 130,000 acres (52,000 ha) of irrigable land, which means that not every acre in the district is irrigable. For example, the district owns almost all of the bosque, but does not irrigate it. Often, as is the case in Albuquerque, the MRGCD lets other agencies manage their lands. Albuquerque Open Space manages the bosque between the Sandia and Isleta Pueblos. The MRGCD is an agency of the State of New Mexico, and thus has a governing board of directors who are elected in local elections. The MRGCD has its own tax base with which to run its operations.

Procedure:

- Comience con una actividad de QAA. ¿Qué **saben** los estudiantes sobre el riego? ¿Qué **quieren** aprender sobre el riego? Después de la actividad, pregunte ¿Qué han **aprendido** sobre el riego? **(Asking Questions & Defining Problems)**

- Discuss students' experiences with irrigation, ditches, etc. *¿Sus familias riegan? ¿Caminan por las acequias en el valle? ¿Qué saben ellos sobre cómo fluye el agua del río y el agua para riego? ¿Qué notan sobre cómo fluye el agua en las acequias y desagües? ¿Cómo se compara / contrasto al flujo en el Río Grande?*

  ¿Qué causa que el río fluya?(Gravedad) **(5.PS2.B)**

  ¿Cómo riegan sus campos muchos de los agricultores del valle? (From ditches. Some use pumps to bring up ground water, but our focus will be those who use ditches/acequias/laterals to irrigate.)

  ¿Qué impulsa el sistema de acequias y desagües? (Gravedad) **(5.PS2.B)**

  Making use of the laws of gravity, irrigation water is distributed throughout the valley. Remember as you work on this activity that water does not flow uphill!

  ¿Dónde colocaría el canal de alta línea? Piense en cómo utilizar la gravedad para regar los campos. (You want to keep the canal along the far edge of the mesa, so it slowly flows downhill. This way you can use gravity to drain into fields toward the river.)

- Think in terms of Systems (see Appendix K). The network of acequias and ditches forms a system to irrigate farmers' fields. *¿Cuáles son los límites, componentes, interacciones, entradas, salidas y características de este sistema?* **(Systems & System Models)**

Start with the Rio Manso model set up

- Divide the class into eight groups and pass out one Working Water card and appropriate items to each group.
- Have students read the cards and place their items on the Rio Manso model when instructed to do so.
- Tell the students to place items on the model in the order given below. Each group should describe what they have placed to the entire class and why they chose to place it where they did.
    - irrigation district
    - diversion dam (at the most upstream location in the district)
    - high-line canal (take in the widest section of the valley to maximize available farmland)
    - lateral ditches and acequias
    - farm fields
    - turnouts for fields
    - check dam to make turnouts work
    - gaging stations where you want to know how much water is being used (at the diversion and other places)
    - drains if they are not already in place

Discussion Questions / Assessment:

Look back at the KWL charts. *¿Qué han **aprendido** los estudiantes?*

¿Qué preguntas adicionales tienen?

Have students think about these ideas:

¿Cómo ha afectado la agricultura al valle del Río Grande? **(Cause & Effect)**

¿Cómo han cambiado las prácticas agrícolas durante el último siglo?

¿Qué proyectos de ingeniería se han construido para proporcionar agua para riego a los agricultores?

¿Qué proyectos de ingeniería protegen a nuestras comunidades de las inundaciones?

¿Qué proyectos de ingeniería ayudan a los agricultores a conservar el agua? **(5.ESS3.C; MS.ESS3.C; MS.ETS2.B)**

Extensions:

- Challenge students to build their own gravity-driven water system (they cannot use a running hose for power!) A tub of water could be their source. They could devise a system to divert runoff water from a roof or parking area to water native landscaping. **(Constructing Explanations & Designing Solutions)**
- Students can research traditional agricultural practices and compare those to more modern agriculture. What are advantages or disadvantages of each system? Have students present their findings using posters, written papers, or other formats. **(Obtaining, Evaluating & Communicating Information)**
- Oral history extension: have students talk with elders about agriculture and specifically about irrigation methods. Students may present their findings using posters, written papers, or other formats. **(Obtaining, Evaluating & Communicating Information)**

NGSS Connections to Working Water: Disciplinary Core Ideas

5.ESS3.C Human Impacts on Earth Systems *Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.*

Humans have made many changes to the Rio Grande Valley, some of them to help farmers get dependable water for their crops. Diversion dams direct water from the river into highline canals and irrigation ditches; deep trenches called drains ensure fields are not water-logged. Levees keep the river from flooding homes and agricultural fields. Water in ditches may help cottonwoods and other native plants grow in places away from the river. While flood irrigation is common in the valley, farmers typically have their field laser-leveled, which reduces water use.

How has agriculture affected the Rio Grande Valley, including the local floodplain ecosystem?
How have farming practices changed over the last century?
What engineering projects have been built to provide water for irrigation for farmers?
What engineering projects or agricultural practices help farmers conserve water?

5.PS2.B Motion and Stability: Forces and Interactions; Types of Interactions *The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.*

The force of gravity acts on water on the Earth's surface, resulting in the movement of water "downhill", toward the center of the Earth. This drives the flow of rivers and the movement of water in irrigation ditches. Farmers use this simple but powerful force to irrigate their fields!

What causes rivers to flow?
What powers the system of ditches along the Rio Grande?

MS.ESS3.C Human Impacts on Earth Systems

-Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

-Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

-The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Humans have made many changes to the Rio Grande Valley, some of them to help farmers get dependable water for their crops. Diversion dams direct water from the river into highline canals and irrigation ditches; deep trenches called drains ensure fields are not water-logged. Levees keep the river from flooding homes and agricultural fields. Water in ditches may help cottonwoods and other native plants grow in places away from the river. While flood irrigation is common in the valley, farmers typically have their field laser-leveled which reduces water use.

How has agriculture affected the Rio Grande Valley?
How have farming practices changed over the last century?
What engineering projects have been built to provide water for irrigation for farmers?
What engineering projects protect our communities from flooding?
What engineering projects help farmers conserve water?

What are positive and negative impacts from agriculture—brainstorm lists of each.

MS.ETS2.B Influence of Engineering, Technology, and Science on Society and the Natural World

The uses of technologies and any limitations on their use are driven by individual or societal needs, desires and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

After years of building structures in the Rio Grande and its floodplain with the goals of reducing flooding, drying out waterlogged soils and delivering water for irrigation, biologists began to see impacts on the bosque ecosystem that were not intended or expected. The cottonwood forest corridor of the river was getting old, with few seedlings growing to replace them. Fish species like the Rio Grande silvery minnow were not finding the shallow, muddy, backwater areas needed to lay their eggs and produce successful fry. Use any of the following ideas after the "Changing River" activity to explore how New Mexicans have urged changes to the management of the river over time and how they are urging preservation of the bosque into the future.

How does the public influence/impact the management of the bosque?
How has the management of the bosque changed from the early 1900s to today? Describe who has influenced changes in management over these decades?

List long term impacts of major engineering projects concerning Rio Grande water, including original intent and unexpected results. Examples: dams, levees, sewage treatment plants, irrigation, agriculture, city water use, straightening the river, jetty jacks, San Juan-Chama diversion, growth of cities, pollution, industry, and mining.

Términos de la Acequia

Acequia: (s) un canal excavado a mano, alimentado por gravedad, que desvía el agua de un arroyo u otra fuente de agua natural para regar campos, huertos y jardines

Acequia madre: (s) Este es el canal principal que toma agua del río y se divide en cada acequia

Atarque: (s) una presa temporal construida a través de un río para desviar el agua hacia la acequia madre

Compuerta: (s) una puerta que regula y divide el flujo de agua

Desagüe: (s) una zanja de drenaje que canaliza el exceso de agua de riego hacia un arroyo

Limpiar: (v) la limpieza en la primavera de las acequias, limpia: (s) evento de limpieza por la comunidad

Lindero: (s) también conocido como sangría, un canal lateral que canaliza el agua de la acequia madre a propiedades individuales

Mayordomo/a: (s) un jefe de zanja que asigna agua y supervisa el mantenimiento de el canal

Milpa: (s) una parcela de tierra utilizada para cultivar maíz

Parciante: (s) un miembro de la zanja o un regador que trabaja las acequias

Presa: (s) una estructura que desvía el agua de un arroyo u otra fuente de agua natural para moverla cuesta abajo a través del canal principal

Regar: (v) proporcionar agua a los cultivos para ayudar al crecimiento, normalmente por medio de canals

Repartimiento: (s) la partición o división de aguas entre acequias que comparten la misma corriente o entre los parciantes dentro de una sola acequia

Sangría: (s) también conocido como lindero, un canal lateral que canaliza el agua de la acequia madre a propiedades individuales

Tiempos: (n) un período de tiempo rotativo en el que se asigna el agua de la zanja

El Agua es Vida, Acequias in New Mexico, Loan Kit Teacher's Guide. Grochowski, A.L. Maxwell Museum of Anthropology, University of New Mexico. 2019.

Working Water Cards

Presa de desvío

Una presa de desvío es una estructura restrictiva que se construye en un río o vía fluvial para que el agua se pueda desviar hacia canales de riego para uso agrícola. Las presas tienen muchos usos y no todas las presas son iguales. Una presa de desvío agrícola típicamente no crea un reservorio detrás de él. Las presas de desvío reducen el flujo del río debajo de la estructura de la presa, atrapan sedimentos y, a veces, actúan como barreras para el movimiento de organismos biológicos.

- Coloque la presa en la parte superior del sistema fluvial donde comienzan los canales de la línea alta.

Canal de alta línea

Un canal de alta línea (llamado acequia *madre* en el norte de Nuevo México) es la arteria principal del distrito de riego. Es el gran canal que lleva el agua de las presas de desvío del río a través del valle o por la fuerza de la gravedad. Los canales de alta línea generalmente se abren en abanico desde el río y se mueven a los puntos más altos del valle que son posibles sin que el agua deje de fluir cuesta abajo. De esta manera, la tierra que está a una buena distancia del río aún puede recibir agua. Una vez lejos del río, el canal de la línea alta generalmente corre paralelo al río. El canal de la línea alta alimenta canales más pequeños llamados laterales y acequias.

- Use la cinta o hilo azul más claro para mostrar el canal de la línea alta.

Canal lateral, Zanja, y Acequia

Todos estos son términos para canales más pequeños que se extienden como una telaraña desde el canal de alta línea. Normalmente, las tierras agrícolas se regarán directamente desde uno de estos canales. Las granjas más grandes también pueden tener muchos canales pequeños para suministrar agua a los campos individuales. Todos estos nombres son intercambiables según la tradición local. Nota: el término acequia se puede aplicar a un canal, pero también es el término utilizado para el pequeño grupo de agricultores que administran un pequeño distrito de riego. El término tiende a usarse en contextos históricos y en áreas de cuencas hidrográficas superiores. Los campos de agricultores se agrupan alrededor de estos canales. Recuerde que se necesita gravedad para mover el agua, por lo que el campo debe estar más bajo que la acequia.

- Utilice hilo azul para mostrar los laterales, zanjas, acequias.

Desvío

Compuerta de desvío
Una compuerta de desvío es una estructura de riego que permite al agricultor verter agua en un terreno desde un canal lateral, zanja o acequia. A menudo, esta compuerta se encuentra por encima de una de una presa (mini-presa). Estas compuertas deben colocarse en los canales de riego en los que se se encuentran los campos. Un sólo campo suele tener varios desvíos.

- Utilice pequeños círculos para representar los desvíos.

Retén o control

Un control es una mini presa en un canal de línea alta o un canal lateral que hace que el agua corriente arriba que se acumule, forzándolo a través de desvíos hacia los canales laterales o hacia los campos de los agricultores. Por lo general, debe haber una control para que un desvío funcione correctamente.

- Coloque un control aguas abajo de cualquier lateral en el canal de la línea alta y otro de cada desvío a un campo en un lateral.

Desagüe a orillas del río

Los desagües del lado del río (desagües interiores) siguen de cerca los contornos del río y sirven para bajar el nivel freático y recolectar agua subterránea, que finalmente se devuelve al río. Aunque también son utilizados en la agricultura, la función principal de estos desagües es recolectar el exceso de agua subterránea y bajar el nivel freático en el valle para que no sea solo un gran pantano. También se les llama "zanjas claras" porque el agua subterránea que recolectan está libre de sedimentos en suspensión. Estos drenajes generalmente comienzan poco después de las presas de desvío y aumentan gradualmente de tamaño a medida que avanzan río abajo. Como los diques, tienden a confinar el bosque dentro de ellos. Es posible que estos ya estén en su lugar con la configuración de Río Manso.

- Coloque los desagües justo afuera de los diques.

Estación de medición

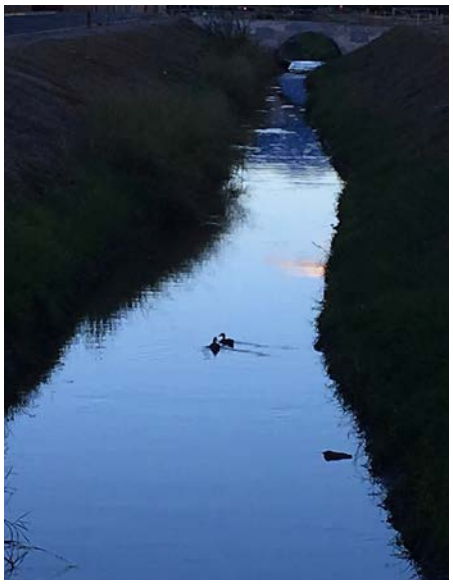
Los hidrólogos utilizan las estaciones de medición para la medición continua del flujo tanto en el río como en los canales de riego. Los modelos más antiguos usan dispositivos físico para registrar los niveles de flujo a lo largo del tiempo, mientras que las estaciones más nuevas de medición de radio y satélites proporcionan datos en tiempo real para ser utilizados en la gestión del río y en operaciones de riego. Por lo general, solo los canales y desagües grandes, así como el río, tienen estaciones de medición. Una buena regla general es "cuanto más escasa el agua, más estaciones de medición".

- Coloque estaciones de medición cerca de las orillas de las vías fluviales principales y uniones críticas en el sistema de riego.

Distrito de riego

Un distrito de riego, como el Middle Rio Grande Conservancy District, está formado por ciudadanos que viven en el valle del río en tierras que tienen la posibilidad de ser irrigadas. No todas las tierras del distrito de riego reciben agua, pero todos los residentes en los límites del distrito pagan impuestos y pueden votar por la junta directiva del distrito. Aquellos que reciben agua pueden llegar a pagar solo una tarifa, si todavía son dueños de los derechos de agua de su tierra entonces legalmente son dueños del agua. El distrito de riego debe incluir cualquier terreno que pueda regarse por la gravedad.

- Utilice hilo negro fino para delinear los límites del distrito de riego.



Un desagüe en el valle baja los niveles de agua subterránea.
Photograph by Mark Higgins

Una presa de desvío del distrito medio de conservación de Rio Grande cerca de Algodones
Photograph by Letitia Morris

La estructura metálica de la izquierda es un retén. Cuando está cerrado, el agua en el canal de la línea alta o en el lateral se acumula hasta un nivel que fluirá a través del desvío, como se muestra en la parte inferior derecha, hacia un campo agrícola o una zanja más pequeña.
Photograph by Anders Lundahl

Schematic of Middle Rio Grande Conservancy District Water System