

El Paso Pollution in Our Waterways and Arroyo Parks

Overview

In this lesson plan students will:

- Understand how water flows from mountains to rivers
- Recognize that the geography of an area can both help and hinder pollutants getting into the waterways
- Evaluate the size of pollutants to their ability to get into the water supply

TEKS Alignment

7.8 Earth and Space. The student understands how human activity can impact the hydrosphere. The student is expected to:

7.8A analyze the beneficial and harmful influences of human activity on groundwater and surface water in a watershed; and

7.8C model the effects of human activity on groundwater and surface water in a watershed

THE SCIENCE BEHIND IT:

In elementary school, students will have learned about water as a system and that the water cycle is a continuous system above and on the surface of the Earth. It isn't until the 7th grade that students learn about groundwater being part of that system. El Paso acts as a perfect backdrop to this lesson as the community draws not only on its surface water (the Rio Grande River) as a source of freshwater for the community, but it also draws upon groundwater resources from the Hueco Bolson Aquifer as part of the water supply.

In this unit students will be discussing the effects of gravity on the El Paso water system as they investigate how arroyos recharge the Rio Grande River and pond areas above the Hueco Bolson Aquifer.

ARROYO FORMATION

Arroyo formation is a common occurrence across the United States and the world. Anywhere that you have water traveling over land from high to low elevations, the result will be an erosion of the land forming channels to take the water to lower elevations with the help of gravity. Once the water source has run through and the water has dried up, the remnants of those channels are left behind, waiting for the next rain or snow pack runoff to fill these channels once again. Arroyo is Spanish for brook and refers to a dry creek, gulch or stream bed.

Grades 7-8

Vocabulary

aquifer

bolson

drainage divide

groundwater

surface water

nonpoint source

pollution

retention ponds

point source pollution

water table

watershed

erosion

runoff

recharge

Water Traveling the Path of Least Resistance with Gravity

If you look at our Franklin Mountain Range, you can see the water channels where water flows from the top of the mountain range towards the bottom. Arroyos channel this water to the points of lowest elevation. The Franklin Mountains is a **drainage divide**, meaning that on one side of the Franklin Mountains the water flows in one direction (towards the Rio Grande River) and on the other side of the Franklin Mountains the water flows in another direction, towards a flat plain area in the valley between the Franklin Mountain range and the Hueco Mountains. This flat depression area is called a **bolson**, and as the water from arroyos collect and pond in the flat area, the water percolates the ground and is stored in water permeable rock underground. This water store is called an **aquifer** and it is one of the water resources drawn upon for freshwater use.

In this unit, the El Paso Water Chronicle will not only describe the ways that gravity influences the formation of rivers but also the formation of arroyo channels that help to keep the river recharged as it travels along the Texas-Mexico border to the Gulf of Mexico. The force of gravity plays a major part in the collections of water for the Franklin Mountain drainage divide. This powerful force can carve and shape the channels and pull water underground. It is important to note that this force is also responsible for pollution ending up in the waterways. Since the river provides El Paso with more than half of its fresh water supply, the chronicle article addresses the need for people in the community to monitor the waterways (both natural arroyos and manmade waterways) so that pollution does not affect our water source. This unit will also address changes in the waterways over time in the activity, Where Have All the Arroyos Gone?

Desert Pollution and Water:

When people dump into the desert, they really don't care WHERE they are dumping. Some people dump right into arroyos. This problem is twofold depending on particle size. Pollutants in our desert come in all shapes and sizes, such as huge blocks of concrete from construction sites, old tires, tree clippings, used motor oil, and even small micro plastic beads too small for the eye to see. The dumping of large items can cause blockage of the waterways that may cause arroyos to change course causing new erosion in areas that were once unaffected. This can cause populated areas to experience flooding which can damage property and streets. For smaller pollutants we know that what is in the arroyos can eventually end up in the Rio Grande. It is a real problem with some severe consequences. Chemical pollutants such as fertilizers, antifreeze and motor oils can get into the water system much faster than large particle pollutants. In the lesson, Race to the River, the students will investigate the possibilities of pollutants getting into the waterways by particle size.

The El Paso Water Utilities has made some videos that address the issue of pollution in our storm drain system and in the deserts around El Paso:

English:



Spanish:



As you can see in the videos, a lot of force is needed to move objects, no matter the type of object. The more massive an object is, the more force needed to move it. Some objects, for example, a 2000 lb. piece of concrete, requires heavy machinery. Others, however, don't require quite as much energy. It is not easy, depending on the circumstance, such as flash flooding, water can move large objects such as the 2000 lb. piece of concrete and cause it to bottleneck or block waterflow areas causing millions of dollars in damage to the community.

Since it is necessary for great force to move a large object, it is therefore, intuitively obvious that the smaller the mass of an object, the easier it is to move and the farther it will move. This is the problem with chemical dumping. Consider this: Suppose someone is working on a car and puts some antifreeze into the street. It may seem harmless since it is a hot day, and the antifreeze appears to evaporate like water. In fact, the antifreeze residue is still there in the street, it's major poisonous components just waiting for a rain or snowstorm to come along so it can dissolve and hitch a ride with a water molecule and head towards the river. Depending on how severe the rain or snowstorm is, the antifreeze might make it into the river the very same day, or it might just move down the street a little on its journey. Objects of small particle sizes such as bacteria, agricultural and municipal waste products, fertilizers, and sewage are a threat to the health of our water system and river. Most pollution in the waterways of El Paso occurs from carelessness of illegal dumping. This type of pollution is described as **nonpoint source pollution** because the pollution cannot be traced to a single source. Students should be encouraged to report illegal dumping by calling 311.

Water Safety in Arroyos and Arroyo Fieldtrips

Arroyo parks are mentioned in the Water Chronicle and would make perfect destinations for fieldtrips. Students can witness firsthand the effects of water erosion, can take soil samples that may contain seeds of life (dormant eggs of brine shrimp and other water life) that lie waiting for the next rain. The amount of water provided by the arroyos can be measured by the presence of trees and large bushes in the park, which will host wildlife. Desert hiking precautions should be observed, such as sunscreen, hats, and water containers. A careful eye should be made for wildlife such as snakes and other predators depending on the time of day that you are exploring the parks. Water safety is especially important when investigating arroyos and walking these paths. The best time to investigate arroyos with students would be on clear dry days when there is no danger of storms. Students should be aware that even if a rainstorm is miles away, water can fill an arroyo quickly and gully washers, fast moving water currents that can create flash floods, can drown innocent hikers in an instant.

Carmen and Ernie Investigate Where Have All the Arroyos Gone, Using Google Earth

Guiding Questions:

- Can I identify the formations of arroyos in the El Paso Area using GPS technology tools such as Google Earth?
- Can I recognize the beneficial and harmful effects of human activity on the land in the El Paso area by using time lapse applications to show changes in El Paso over time?

Materials:

- El Paso Water Chronicle: Issue 3, El Paso Waterways: A System Formed Through Gravity
- Computer, Chromebook or other internet connected device (tablet)
- Google Earth: <https://earth.google.com/web/>
- Printer
- Marker
- Screen capture program such as Screencastify or Screencast-O-Matic
- Printed Versions of the Google Maps Activity Procedure Card (optional)

The teacher may prepare the following for students to make the activity more accessible depending upon the availability of computer devices per student.

1-1 Devices:

1. If using a classroom learning management system like Schoology or Google Classroom, create a link to Google Earth for easy access. The procedure card can also be attached to the online assignment to save on printing, however it may be easier for the students to have the procedure printed so that they do not have to toggle between open windows to follow the directions.
2. Using the Google Chrome Browser would work best for this activity. Make sure that a screen capture program is available to students to use as they are doing this activity. They will be making screenshots and a video of the changes overtime. Free screen capture programs such as Screencastify or Screen-cast-omatic can easily be added as Google Chrome extension without having to download programs to the device. Chrome extensions can be added to devices school wide through the district technology department, or the students can log in to the Google Chrome Store to add the extension. You can send the link to the students to add the extension through the Google Classroom Assignment. Mac devices have screen capture software called Screenshot (MacOS). Windows devices can capture a screen by pressing Windows Key + Alt + R..
3. Create a “how to record” video or write instructional procedure for the recording application so that the students can easily record the change over time, example: “Click on Screencastify on the Chrome browser and press the blue record button when recording the changes.”
4. Practice doing the Google Earth procedures first without students so that you are familiar with both Google Earth and the screen capture programs. Modeling the procedure on a projector or viewboard would allow students to see how to do the assignment if they run into problems.

Limited Device Access:

If there is a shortage of computers for all of the students to complete the investigation at once, the investigation can be done as a center or station. Here is the prep for this version of the activity:

1. Print the procedures and set them up in the station with 1-4 devices ready to do the activity
2. Make sure that the screen capture program is available on either the chrome browser or present on the computer device and that all devices have internet access before starting the activity

- Directions for the activity can be flipped by producing a how-to video for the students so that the station will not need the direction of a teacher in order to get started.

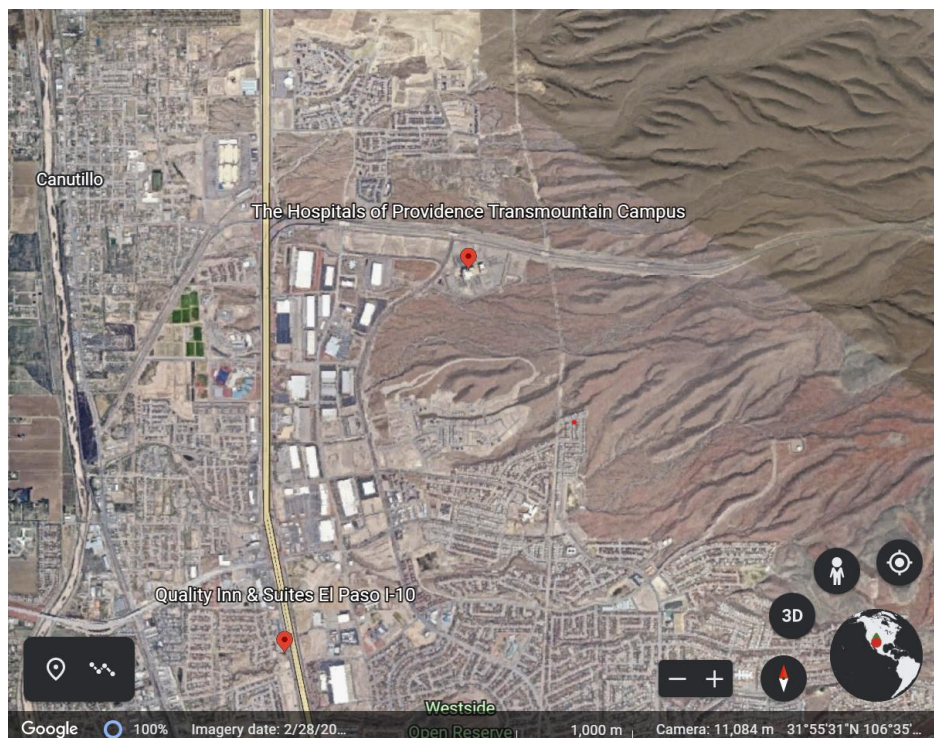
Engage:

The teacher will have the students read and discuss the El Paso Water Chronicle: Issue 3 El Paso Waterways: A System Formed through Gravity.

Explore: Google Maps Activity Part 1: Identifying Arroyos

During Part I of the Google Earth Activity (see procedure card), students will be investigating the Franklin Mountain area to look for arroyo formations on the west side of the mountain. They will be guided to narrow their view to an area at the juncture of Interstate 10 and Transmountain Road and will be asked to take a screen shot of this area so that they can inventory arroyos in the area. The check for understanding tasks and questions will ask them to take screenshots of the section capturing arroyos south of Transmountain Road to where neighborhood development begins.

Below is an example of the screen capture from the Google Earth Activity Part 1 that shows arroyos near the juncture of Interstate 10 and Transmountain Road:



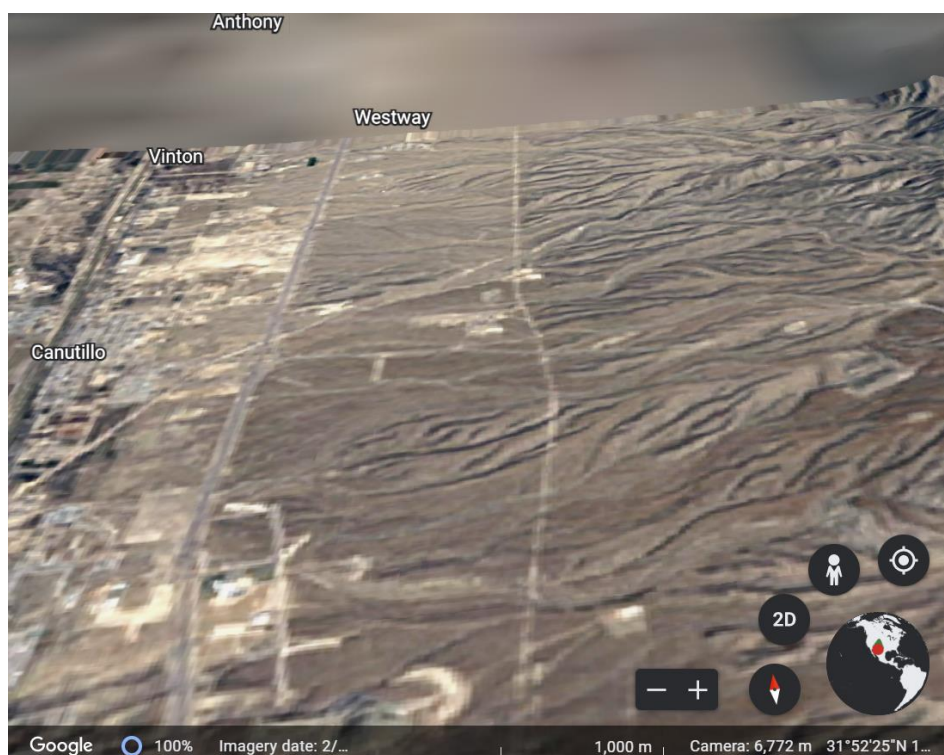
Explain: El Paso Water Chronicle Revisit

In between doing Part 1 and Part 2 of the Google Maps Activity, the teacher may want to revisit the Chronicle article to discuss information provided about natural arroyos verses manmade arroyos.

Elaborate: Google Maps Activity Part 2

In Part 2 of the Google Earth Activity (see procedure card) students will be guided to use the time lapse features of Google Earth to track the development of the area at the Junction of Interstate 10 and Transmountain Road from the years 1985 through 2020. Again, students will be asked to take screenshots of certain years of development as well as video of the changes occurring in that area.

Below is an example of the screen capture from the Google Earth Activity Part 2 that shows arroyos near the juncture of Interstate 10 and Transmountain Road in 1985:



Evaluate

Have the students investigate the areas described on the Google Earth Procedure Card. There are Check for Understanding tasks at the end of Part 1 and Part 2 of the procedure. Students can provide evidence of doing the activity by recording their answers in a science journal, typing their answers into a document or creating a PowerPoint or Google Slide show presentation.

Carmen and Ernie's Race to the River Activity

Guiding questions:

- What type of pollution will most likely make its way to our waterways and rivers?
- How does mass affect the travel of objects through a waterway?

Materials:

- Arroyo Race to the River Gameboard
- Arroyo Race to the River Procedure and Data Collection Sheet
- Pencil
- 2 standard dice
- 3 objects (small, medium and large, 5 cm max) that will represent pollution that may end up in an arroyo or 3 rocks such as a small pebble, medium pebble and a small rock

Teacher Preparation:

Students can do this activity alone, in pairs or in groups, but it is generally better if all students that participate have a chance to do at least one set of data collection. Prepare materials for participation depending on the number of dice sets you have available for your classroom.

Game and Data Collection

In this activity, students will be using probability to determine if the mass of an object has an affect on whether the object will travel through a waterway and how far it is likely to travel. Students will play the game multiple times (10 times) and collect data on how far each object travels through the arroyo gameboard. They will then use the data to determine if the size and mass of the object effects the distance traveled.

At the end of the data table there are some response questions. Students can answer these questions in their science journal, pen and paper, or by document.

Discussion Points and Extensions:

Use the El Paso Water Chronicle, Issue 3, to revisit information regarding pollution in the waterways and how this game may relate to local issues with waterway dumping and chemical pollution. Show the El Paso Water Utilities video (cited in the Teacher Background information of this lesson) to show real world examples of illegal dumping.

Erosion Extension for the Arroyo Race Game:

To show the affects of erosion that large objects may cause in an arroyo blockage, have the students play the game again, but this time if one of the game pieces lands on a part of the board

that a larger piece is on, the game piece can jump to the next corresponding color on the board, which would mimic a direction change in an arroyo when the arroyo path is blocked.

COMIC by Ernie



WATERWAYS WORD SCRAMBLE by Carmen

Unscramble the words to find out the type of pollution that we can prevent to protect our river.



ONUFRF

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EL PASO WATER CHRONICLES

The Latest News in Water and Science from El Paso



IN THIS ISSUE

EL PASO WATERWAYS: A SYSTEM FORMED THROUGH GRAVITY

El Paso Waterways: A System Formed Through Gravity

by TecH2O

In El Paso, water flows towards the Rio Grande. It is the 4th longest river in the US and travels 1,885 miles, from the San Juan Mountains in Colorado, at an elevation of 12,000 feet. Water from the snow melt of the Rocky Mountains flows from Colorado to Texas. By the time the water is in El Paso, the elevation has dropped to 3,740 feet above sea level. Gravity continues to pull the water to the Gulf of Mexico, where the elevation is 0 feet, or sea level.

THE PATH OF LEAST RESISTANCE: EL PASO'S ARROYOS

ARROYOS ARE THE RIO GRANDE AND HUECO BOLSON'S FRIEND

EL PASO USES NATURAL AND MANMADE ARROYOS

CARE AND UPKEEP OF EL PASO'S WATER DRAINAGE SYSTEM

COMIC

WORDSEARCH

The Rio Grande River channel has cut through the bedrock over millions of years, winding and following the lowest elevation because of gravity. The water in the river is seasonal and not only comes from snow in Colorado, but also from the precipitation flowing from mountains and higher ground running along the river's path. This is known as runoff, and it helps recharge the river as it flows to the Gulf of Mexico.

During El Paso's rainy season, the river is recharged through naturally created paths that flow into its banks. These paths are created not only because of gravity pulling the water from high to low ground but also because water seeks an easy path to flow.

The Path of Least Resistance: El Paso's Arroyos

Geologists say that "Water seeks the path of least resistance." That means that in addition to the effect of gravity, water will flow in places where it is easy to do so.

Places with less boulders, less vegetation, and less obstacles, means less resistance. In El Paso and the surrounding areas, there are small stream channels called **ARROYOS**, carved out by water and gravity over time and following the paths of least resistance. (Arroyo is Spanish for brook and refers to a dry creek, a gulch, or a stream bed that momentarily fills up and flows when there is a heavy rainfall.) Arroyos are not as long as a river but can wind for miles. They are formed through the erosion of loose sandy soil, easily moved because our Chihuahuan desert has sparse vegetation to hold the soil in place.



NOTE: NEVER HIKE IN AN ARROYO IF THERE ARE RAINSTORMS NEARBY

To hikers, arroyos seem like easy flat paths in the desert, however, rainwater can travel long distances in a short period of time in an arroyo. Even if a rainstorm is several miles away, water can fill an arroyo and dangerously gain momentum towards unsuspecting hikers.

Arroyos are the Rio Grande and Hueco Bolson's Friend

Arroyos are important for recharging our **surface water**, the Rio Grande River and our **groundwater** in the Hueco Bolson Aquifer. During El Paso rainstorms, arroyos channel our water through a **drainage divide**. A drainage divide happens when the runoff from rain or snow heads in different directions because of a land feature such as mountains. On the west side of the Franklin Mountains, arroyos make their way off the mountain to help replenish the Rio Grande. In fact, arroyos are responsible for replenishing this river along almost all of its 1,885 miles, but they are especially prominent in desert areas. On the other side of the divide, on the east side of the Franklin Mountains, arroyos tend to drain into the flat plain areas between the Franklin and Hueco Mountains. This valley depression is called a **bolson** and allows for runoff to recharge the groundwater through a process called **percolation**. Gravity pulls the water through the soil to the Hueco Bolson Aquifer located underneath El Paso. The **aquifer** is made of permeable rock that can store the water. El Paso uses this aquifer to draw some of its water for the community.

El Paso Uses Natural and Manmade Arroyos

In El Paso, arroyos are so important that we celebrate them! There are several nature trail parks that are located inside the city such as the Wakeem-Teschner Nature Preserve and the Billy Rogers Arroyo Park, both located west of the Franklin Mountains. These parks are arroyos that are used as hiking and nature trails during dry weather.

There is a very good chance that where you live in El Paso there once was a natural arroyo nearby. As the city grows, more and more natural arroyos are replaced with artificial arroyos. These arroyos can take many forms, but most artificial arroyos are streets. El Paso receives only 8 to 10 inches of rainfall annually, making the decision to use streets as temporary arroyos practical and money saving. El Paso streets are our method for channeling rainwater away from places where it can do damage. During heavy rainstorms it is best not to travel while the streets direct water to the drainage areas.

Another manmade form of redirecting water is with **retention ponds**. These are cement lined channels or tanks where water can collect and can be directed toward the Rio Grande. Because natural arroyos are prone to erosion, a man-made arroyo or pond can serve as a more permanent structure to collect and direct El Paso's water during the monsoon season.



***El Paso Streets Are Man Made Arroyos:** Keeping El Paso waterways free of debris is the job of everyone.*

Care and Upkeep of El Paso's Water Drainage System

No matter how good a plan is to direct water back to our river and bolson, if the arroyos and reservoirs are not kept clean of debris, water's path of least resistance can be blocked and flooding can occur. Huge blocks of concrete from construction sites, old tires, worn out furniture, mattresses and other large items normally taken to the city dump have been found disposed of in our waterways causing neighborhoods to flood and millions of dollars of damage. Despite this, the most dangerous pollutants to our water are often the smallest. Small particle pollutants from fertilizers, pesticides, industrial waste, bacteria, and municipal waste products all can contribute to declines in river biodiversity as well as cause health hazards.

Water pollution is often categorized as "point source" or "non-point" source pollution. **Point source pollution** can be tied to a particular location; whereas **non-point source pollution** comes from sources that cannot be traced back to a single point of origin. Most pollution to the Rio Grande in El Paso is non-point source, such as debris in our arroyos, motor oil, lawn fertilizer and antifreeze runoff. However, we do share our river with other communities in Texas, New Mexico, and Mexico, and the river is threatened by point source pollution discharged at a single point from some farms and industries along the river. Projects such as the American Heritage River Project seek to fund cleanup and reduce environmental factors contributing to river degradation. El Paso Water's river treatment plants use several effective processes to remove contaminants and make the water safe to drink. The City of El Paso Environmental Services Department and the El Paso County Water Improvement District #1 join forces to raise awareness of the dumping problem, and to remind citizens to be watchful, take a stand and report illegal dumping by calling 311.

Carmen & Ernie's **ARROYO RACE**

OBJECT OF THE GAME:

To see which object, a large, medium or small size has the greatest chance of traveling through the arroyo and ending up in the river.

MATERIALS:

- Arroyo Race Board
- Pair of Dice
- 3 objects representing large, medium and small objects
- Data Table



ARROYO GAME RULES:

- All 3 objects start at the Arroyo at the top of the board.
- Role the die.
- Move the objects 1 space in the arroyo based on the following:
 - Role of 2-5 : Move the MEDIUM Object 1 space
 - Role of 6-9: Move the SMALL Object 1 space
 - Role of 10-12: Move the LARGE object 1 space
- Begin at the top of the arroyo and move the objects based on the role of the die.
- If the object lands on a square that already has an object, the arroyo changes course and you can skip to the next square of the same color.
- The game ends when one of the objects makes it to the river.

After each game, record the number of spaces each object moved. For instance if the large object only moved 5 spaces, then the first result would be 5 in the large column. If the medium object moved 16 spaces it would be recorded as 16 and so on.

The game must be played at least TEN TIMES so that you can collect enough data from the results. You may combine your results with the results of other members or groups.

Using the results from the data, answer the questions on the next page. Based on your game results, put the list of arroyo pollution in order from “Most likely to make it to the River” to “Least likely to make it to the river”



ARROYO RACE DATA TABLE



GAME	LARGE OBJECT SPACES MOVED	MEDIUM OBJECT SPACE MOVED	SMALL OBJECT SPACES MOVED
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average spaces per game			

Based on your results, what type of object (small, medium or large) is most likely to end up in a river or other water supply? Use your data to justify your answer

What type of foreign object may be most likely to lodge in an arroyo, drain, or waterway, blocking flow and potentially causing flooding in other areas? How does mass affect the travel of these objects?

What type of pollution would be most likely to affect the quality of water in the river? Justify your answer.

Based on your results, put the following in order from MOST LIKELY to LEAST LIKELY
To end up in a river from an arroyo:

- Car Tire
- 2000 LB Concrete block
- Paper cup
- Aluminum Can
- Motor Oil that has been absorbed in the sand
- Large Cardboard Box
- 50 pound rock
- A Dried up Christmas Tree
- A molecule of fertilizer
- A plastic bead

LEAST LIKELY

A vertical stack of 10 horizontal bars with rounded ends, used for ranking items. The bars transition in color from dark teal at the top to light cyan at the bottom.

MOST LIKELY

ARROYO RACE

Race from the arroyo to the river



1.5 million tons of tire particles end up in the US environment every year

ARROYO



Motor oil does not dissolve in water and can be toxic to people, wildlife and plants



The US throws away 18.2 million mattresses per year with only 56 recycling centers for the entire country!

Fertilizer run-off can cause aquatic dead zones in coastal areas



Every day 8 million pieces of plastic pollution finds its way into our oceans

Antifreeze is highly toxic and can pollute water supplies if dumped, spilled or leaked.



RIVER



Americans throw away 1 million tons of aluminum trash per year, enough to build a fleet of airplanes



Video links to accompany Pollution in Arroyos and Waterways

Arroyos systems formed through gravity:

<https://youtu.be/koKgaPmSb18?si=xOqrmDysOLdNweft>

Carmen and Ernie's arroyo race:

https://youtu.be/L6C6lgGy_To?si=FSEfEAt74ySKf9id