Oklahoma's Inland Waterway:
The McClellan–Kerr Arkansas River Navigation System

Objective
Students will read about river navigation and transportation of agricultural products by barge. Students will compare transportation by barge with transportation by truck and railroad. Students will build lock systems to see how barges move from one level to another.

Background
Before there were planes, trains and automobiles, rivers carried people and **goods** from place to place. In what we now know as Oklahoma the Arkansas and Red rivers provided a connection with the Mississippi River, which carried goods to settlements in the east and to the Gulf of Mexico. The Arkansas and Red rivers are **tributaries** of the Mississippi.

Tributaries of the Arkansas carried goods further inland, but they were too narrow and shallow for larger craft. Native people used pirogues, or dugout canoes, to paddle upstream. French trappers and traders loaded pirogue with deer, bear, otter, beaver and buffalo to take to American trading posts along the river.

Steamboat travel down the Mississippi River was first achieved in 1812. After that river trade between Fort Gibson and all ports downriver to New Orleans was steady and active. On upriver trips steamers carried **frontier trade goods**. Downriver they carried cotton. The first steamboat to go up the Arkansas River to Fort Smith was the "Robert Thompson," which landed at that post about the middle of April, 1822, with a **keel-boat** in **tow**.

Steamboats dominated trade and travel until the 1900s when newer and cheaper forms of transportation replaced them. Railroads began competing with steamboats in Oklahoma and Indian territories soon after the Civil War. In the 20th Century, with the invention of automobiles and airplanes, steamboats became **obsolete**.

In the late-nineteenth century various groups tried to revitalize navigation on the Arkansas River, linking Oklahoma with inland ports on the Ohio, Illinois and Mississippi Rivers and sea ports around the world, via the Gulf of Mexico. But it was the need for flood control that finally motivated two lawmakers, one from Oklahoma and one from Arkansas, to push legislation that would finally bring an inland port to Oklahoma.

Bob Portiss, Port Director of the Tulsa Port of Catoosa, explains the history of the McClellan Kerr Arkansas River Navigation System (MKARVS)

> *In the '30s, Oklahoma was known as the dust bowl. And it wasn't just Oklahoma, it was this entire area. We suffered an incredible drought at the same time the nation was going through the worst depression it had ever experienced. Then we came out of the dust bowl in the early '40s, and nature decided she'd reverse the trend and gave us so much*

Oklahoma Academic Standards

GRADE 3

Algebra: 2.1. Measurement: 2.3,4,5. Data: 1.1
Economics: 2,3. Geography: 1C, 2C

GRADE 4

Algebra: 2.1,2.
Measurement: 2.4,5. Data: 1.2
Geography: 1A, 2D, 4, 5

water that we had some horrendous flooding – not only in our own state, but in Arkansas and Kansas.

Senators Robert S. Kerr of Oklahoma and John McClellan of Arkansas decided something had to be done about the flooding of the Arkansas River. They asked Congress to approve a flood control project at a cost of a half billion dollars. Congress declined because of the cost.

The senators tried another angle, proposing that the flood control project could also provide benefits like commercial navigation, wildlife conservation, municipal water, and hydro-electric power.

In 1946, Congress passed the Rivers and Harbors Act, authorizing the construction of a multi-purpose waterway originating at the Tulsa Port of Catoosa and running southeast through Oklahoma and Arkansas to the Mississippi River, by way of three rivers: the White, the Arkansas, and the Verdigris.

Construction of the McClellan–Kerr Arkansas River Navigation System began in 1950. The first section, running to Little Rock, opened in January, 1969. The federal government spent $1.2 billion to complete the system. The Oklahoma portion offers two public ports, Catoosa and Muskogee, and several private ports.

To allow for navigation, the Army Corps of Engineers had to compensate for a drop of 420 feet between Tulsa and the Mississippi River. Eighteen **locks** and **dams** create a staircase from the Mississippi River up to Catoosa. Dams artificially deepen and widen the Arkansas to make it **commercially** navigable.

The first barge to reach the Port of Catoosa arrived in early 1971. Today, the Port is one of the largest, most inland river ports in the US. It hosts 70 companies that employ over 3,000 people. In an average year, some 13 million tons of cargo is transported on the McClellan-Kerr by barge; 2.7 million tons move in and out of Catoosa, alone. Numerous industries use water transport to ship bulk freight, including fertilizer and agricultural commodities like wheat and soybeans. Oklahoma is in the grain belt of the US, and a tremendous amount of grain is shipped to New Orleans for foreign markets.

All the ports along the waterway compete with rail and truck transport, but for some customers, water transportation is the only solution. Farmers in southeast Kansas, for example, would not be able to get their goods to market and be competitive in a global market if not for the waterway.

Commercial activity includes up-bound barges of bauxite, grain, chemicals, fertilizer, steel, pipe, asphalt, soda ash, petroleum products, clay, sand, gravel and miscellaneous commodities. Down bound barges ship soybeans, wheat, lumber, steel, coal, gypsum, scrap iron, rock, refined petrleum products and manufactured equipment.

The total length of the system is 445 miles.

Source: “The Tulsa Port of Catoosa: Where the Barges are Running,” *Business Review Magazine*, November 7, 2016; https://www.businessviewmagazine.com/the-tulsa-port-of-catoosa-where-the-barges-are-running/

Some facts about the McClellan–Kerr Arkansas River Navigation System (MKARNS)

- You can ship a bushel of wheat from Tulsa to New Orleans on the MKARNS for a little more than the cost of a postage stamp
- Food and farm products shipped annually on the MKARNS—288,000 tons, $47 million
  - wheat —803,700 tons, $129 million
  - soybeans—365,600 tons, $120,648,000
  - chemical fertilizer—1,931,750, $697 million
- A 2001 study showed that moving freight by barge resulted in cost savings of $68 million for Oklahoma farmers, manufacturers and consumers, compared to the cost of alternative overland modes.

Online Resources

A compressed video of what it’s like to lock through Robert S. Kerr Lock 15. https://www.youtube.com/watch?v=ZIxU1gzN2UI

Inland Waterways of the US: http://www.okladot.state.ok.us/waterway/pdfs/inland_waterways.pdf

Procedures

1. Read and discuss background and vocabulary.
   —Students will locate the Arkansas, Verdigris, Red and Mississippi rivers on a map of the US.

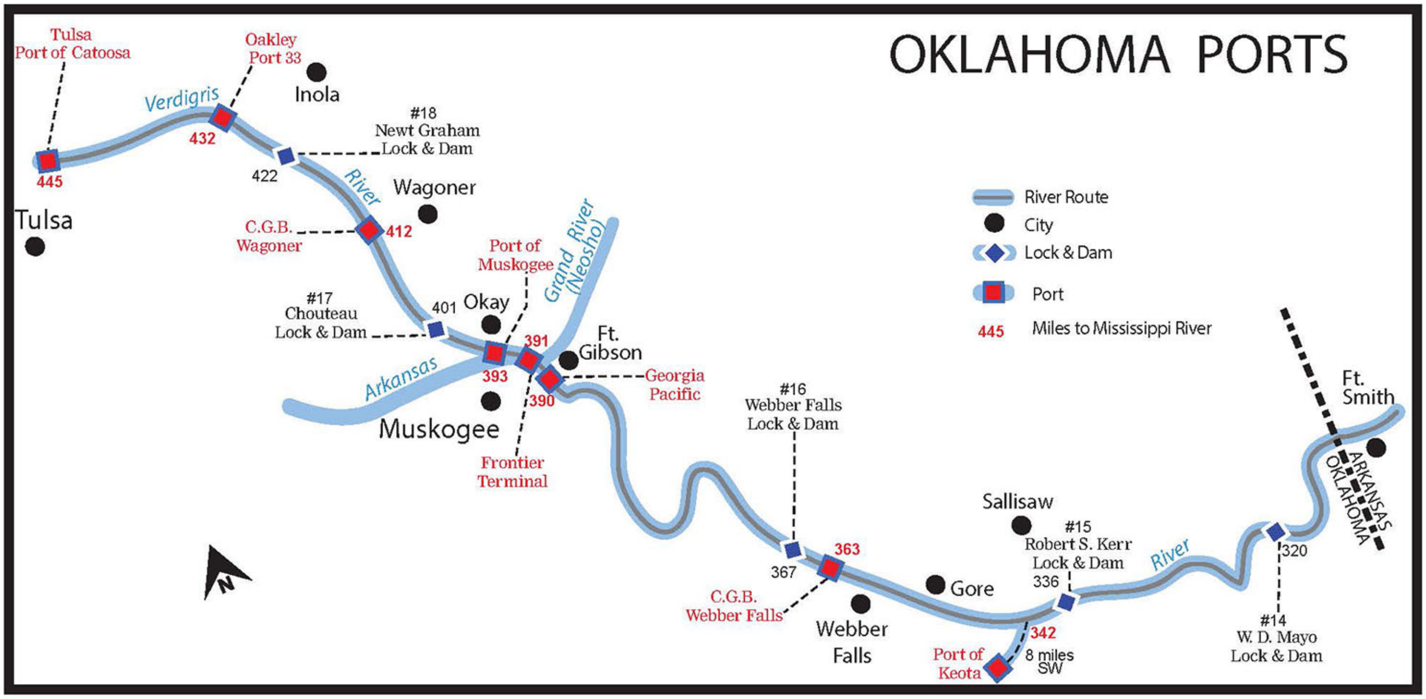
Barge transportation is much more efficient than rail or truck per ton of freight moved per mile. Benefits also include reduced noise, air pollution, and roadway congestion. One barge carries as much as 15 boxcars and 60 trucks.

2. Provide copies of the train, truck and barge patterns.
   —Students will name their farms and design logos for their farm trucks. Students will draw the logos on the sides of the trucks. Each student should make enough trucks so there is a class total of 60.
   —As a class, glue 60 trucks end to end to form a caravan of trucks.
   —Students will hold and stretch out the truck caravan while others measure the length of the caravan to the nearest whole centimeter or meter and the nearest whole yard, foot or half inch. If possible, tape the caravan to the wall.
   —Students will design railroad boxcars for their farms, using the pattern.
   —As a class, students will glue 15 boxcars end to end to form a train.
   —Students will hold and stretch out the grain and measure the length to the nearest whole centimeter or meter and the nearest whole yard, foot or half inch.. Tape the train to the wall beneath the truck caravan.
   —Students will design barge containers for their farm.
   —Students will glue 15 containers (3 rows of 5) to form their barge tow.
   —Students will hold up the barge tow and measure the length to the nearest whole centimeter or meter and the nearest whole yard, foot or half inch..
   —Students will solve the following problems:
   - How much longer is the truck caravan than the train?
   - How much longer is it than the barge?
   - How much longer is the train than the barge?

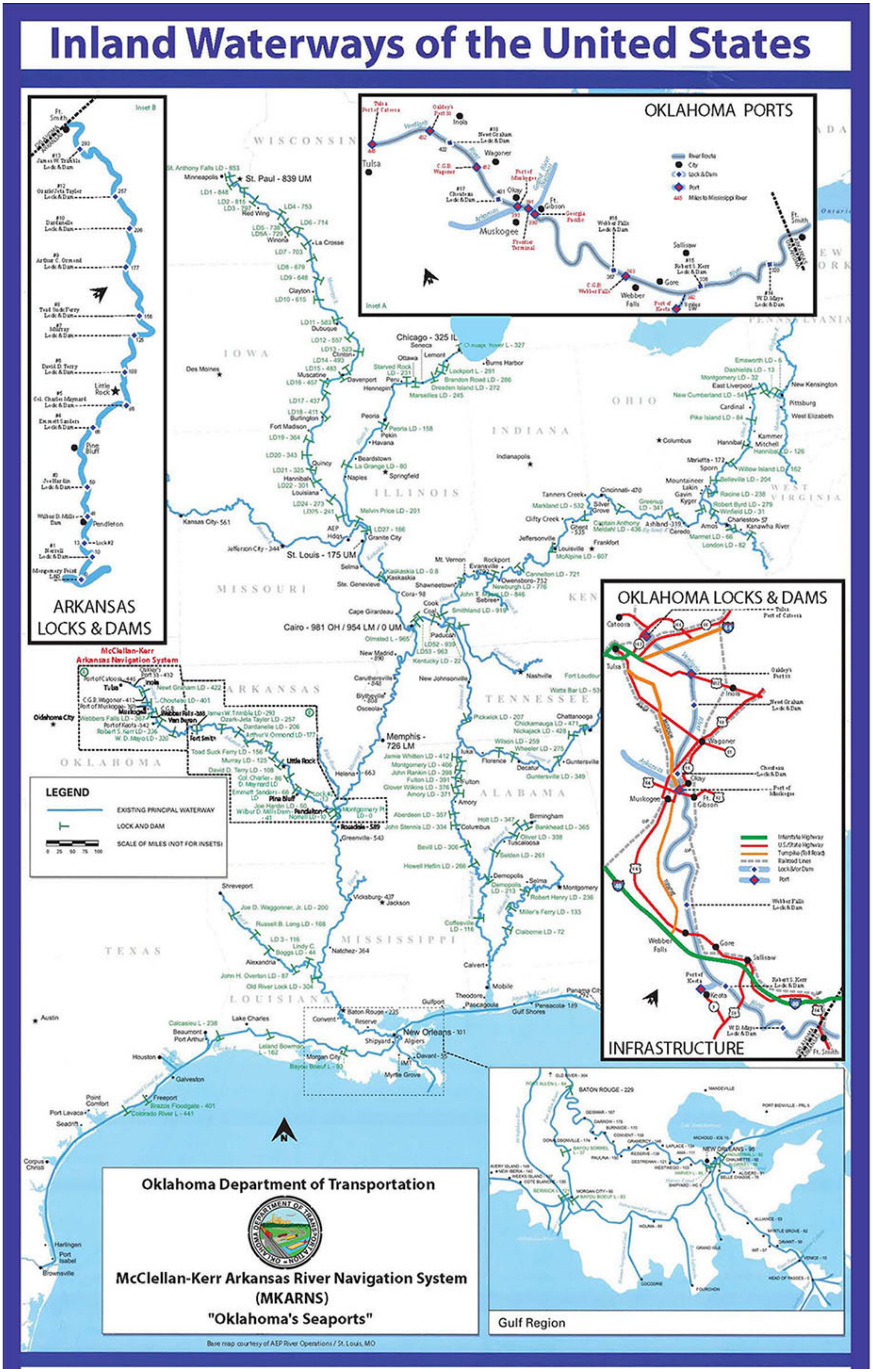
   —Discuss: Which do you think is the best way to move commodities?
   —Students will develop bar graphs to compare what can be carried on the various forms of transportation.
3. Hand out copies of the Fuel Consumption comparison chart included with this lesson.
   —Students will answer the questions based on the information found on the chart.
   (Activities 1 and 2 adapted from Budde, Margaret, and Tanna Nicely, “Exploring the Economics of Using Barges on the Mississippi River to Transport Agricultural Commodities,” http://naitcconference.usu.edu/archive/2016/Uploads/pdfs/14601_2188MargaretBudde.pdf)
4. Read and discuss “How Does a Lock Work?
   —Students will work in groups and follow the instructions included with this lesson to make their own locks.
   (Adapted from “From Lazy River to Deep Water,” Iowa Public Television, http://www.iptv.org/mississippi/lessonplans/ActivityPDFs/Science/FromLazyRiver.pdf)

Vocabulary

barge— a roomy usually flat-bottomed boat used chiefly for the transport of goods on inland waterways and usually propelled by towing
barter— to trade by exchanging one commodity for another
channel— the deeper part of a river, harbor, or strait
commercially— occupied with or engaged in the buying or selling of commodities on a large scale involving transportation from place to place
commodity— a product of agriculture or mining
dam— a barrier preventing the flow of water
frontier— a region that forms the margin of settled or developed territory
goods— something manufactured or produced for sale
hogs-head— a large cask or barrel
keel-boat— a shallow covered riverboat that is usually rowed, poled, or towed and that is used for freight
landing— a place for discharging and taking on passengers and cargo
lock— an enclosure (as in a canal) with gates at each end used in raising or lowering boats as they pass from level to level
navigable— deep enough and wide enough to afford passage to ships
peltry— pelts, furs, especially raw undressed skin
reservoir— an artificial lake where water is collected and kept in quantity for use
tow— to draw or pull along behind
trade— the activity or process of buying, selling, or exchanging goods or services
tributary— a stream feeding a larger stream, river or lake



OKLAHOMA PORTS
Tulsa
Port of Catoosa
445
Oakley
Port 33
432
Verdigris
River
Inola
#18
Newt Graham
Lock & Dam
422
Wagoner
Tulsa
C.G.B.
Wagoner
412
#17
Chouteau
Lock & Dam
401
Okay
Port of
Muskogee
Grand River
(Neosho)
391
393
390
Ft.
Gibson
Georgia
Pacific
Arkansas
Muskogee
Frontier
Terminal
#16
Webber Falls
Lock & Dam
367
363
C.G.B.
Webber Falls
Webber
Falls
Gore
Sallisaw
#15
Robert S. Kerr
Lock & Dam
336
342
Port of
Keota
8 miles
SW
River
320
#14
W. D. Mayo
Lock & Dam
Ft.
Smith
ARKANSAS
OKLAHOMA
River Route
City
Lock & Dam
Port
445
Miles to Mississippi River
N



Larger version of this map: http://www.okladot.state.ok.us/waterway/pdfs/inland_waterways.pdf

Trucks, Trains and Barges

In the US, commodities are shipped by truck, rail or barge. Tractor trailers may be the first method of transporting some commodities from the farm to the processing plant. They also may be used to transport the proceessed product.

One large semi is 73 feet long and can transport

26 tons
910 bushels
7,865 gallons

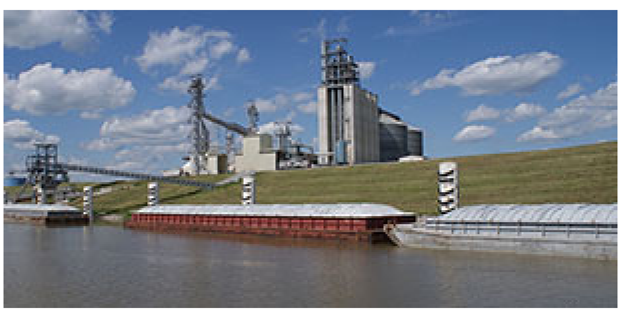
870 trucks are 7 1/4 miles long.

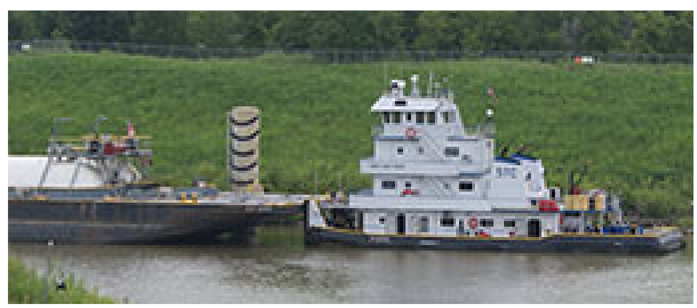
From the processing plant, the product may be loaded into railroad hoppers, or boxcars. Sometimes the box cars are used to carry the goods to the port to be loaded onto barges.

One jumbo box car is 55 feet long and can transport

112 tons
4,000 bushels
33,870 gallons

200 railroad cars are 2 1/4 miles long





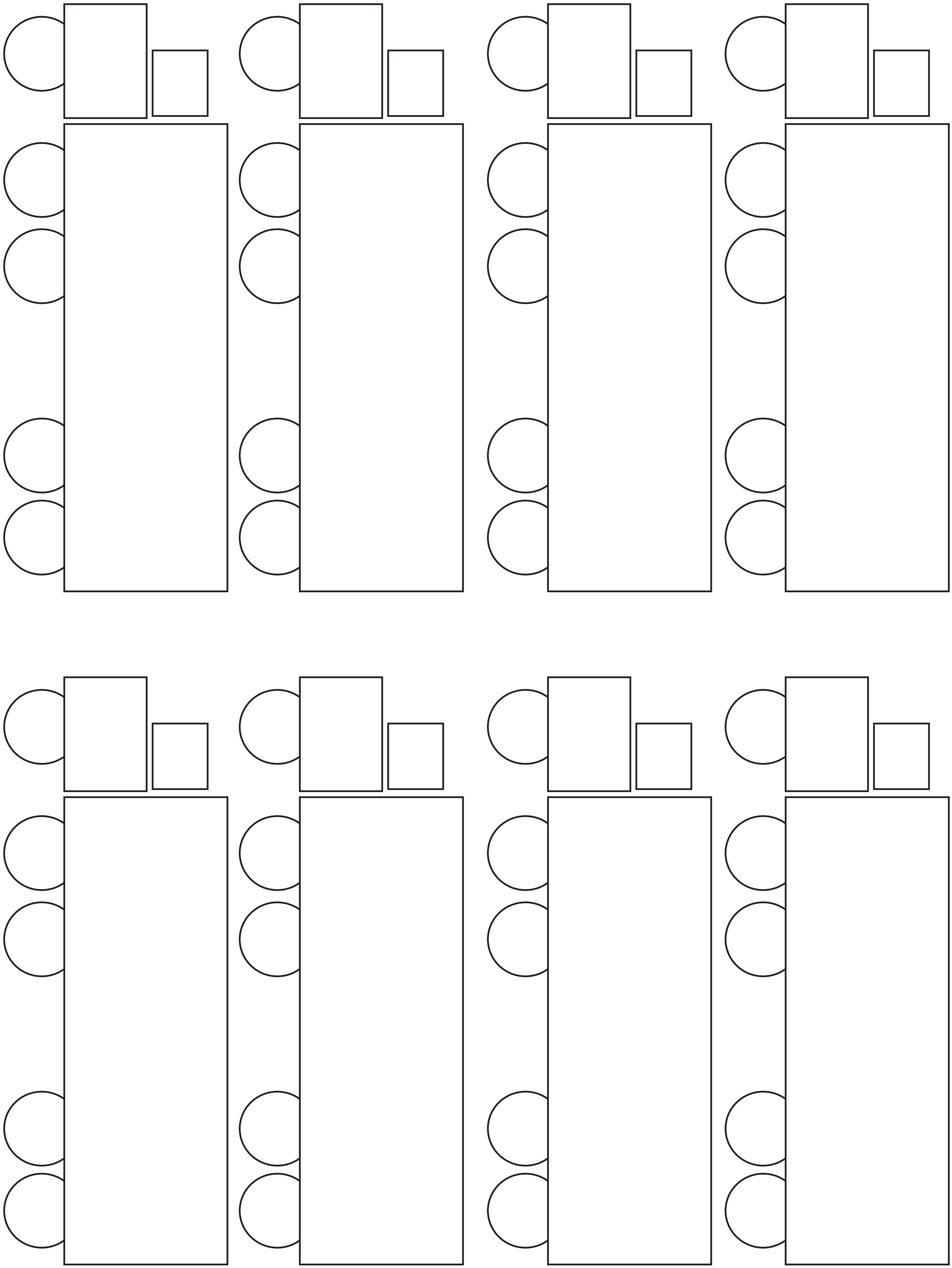
Barges are flat-bottomed vessels built for river and canal transport of heavy goods. One barge is 195 feet long and can carry the weight of 136 school buses, 750 pickup trucks, 12,000 refrigerators, or 200 elephants. Barges are moved up and down the river by tow boats. A set of barges moving together is called a tow. A tow usually has at least 15 barges.

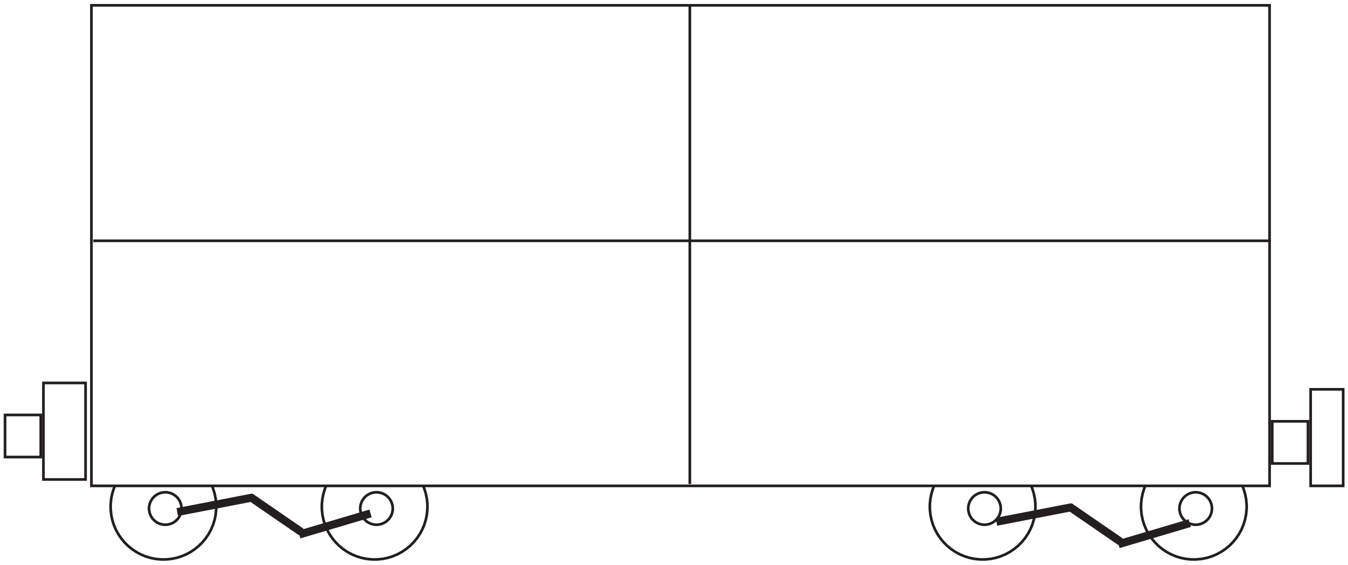
One barge can transport

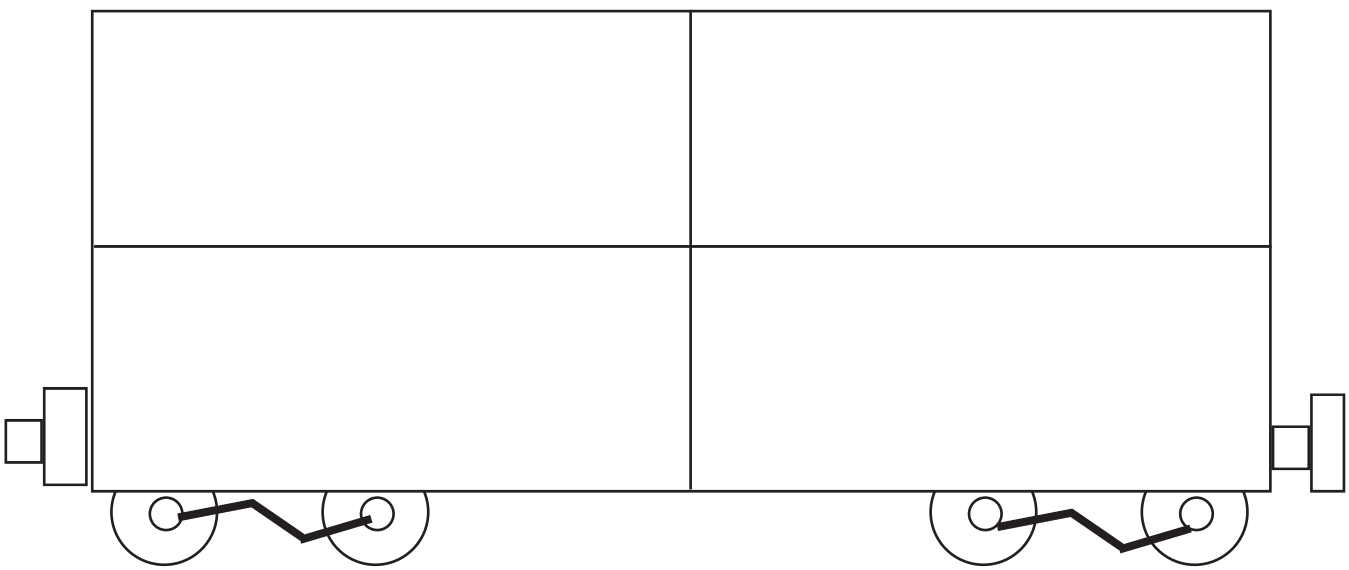
- 1,500 tons (the weight of 136 school buses, 750 pickup trucks, 12,000 refrigerators, or 200
- elephants)
- 52,500 bushels
- 453,600 gallon

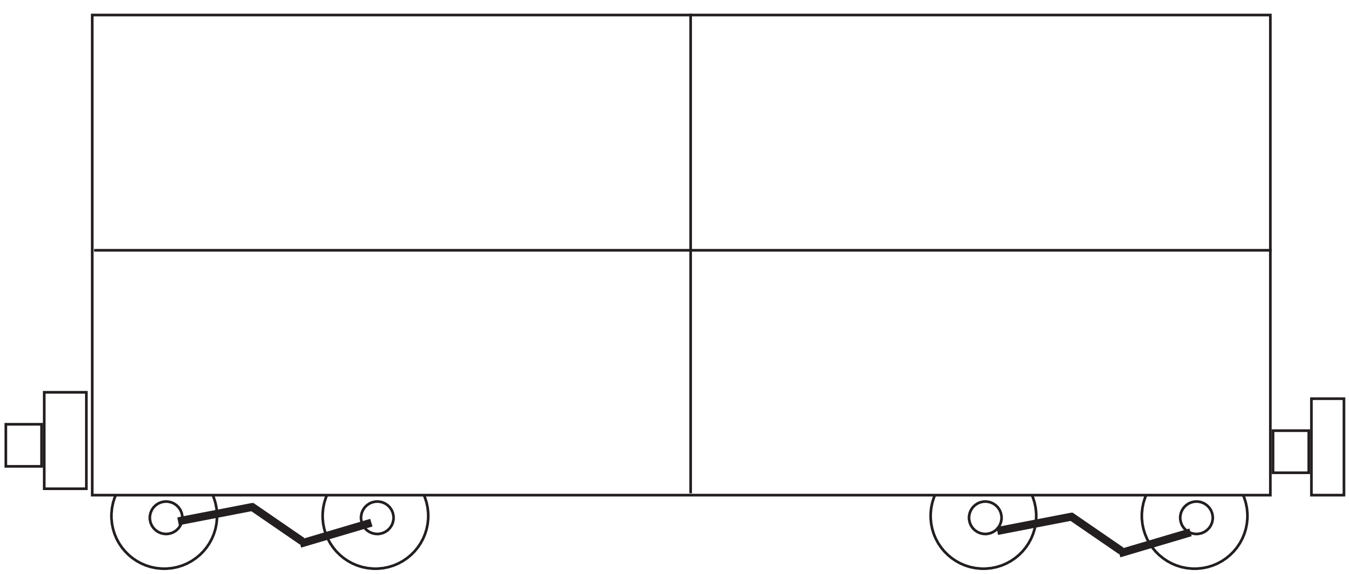
One 15-barge tow is 1/4 mile long and can transport 22,000 tons, 787,500 bushels, and 6,804,000 gallons

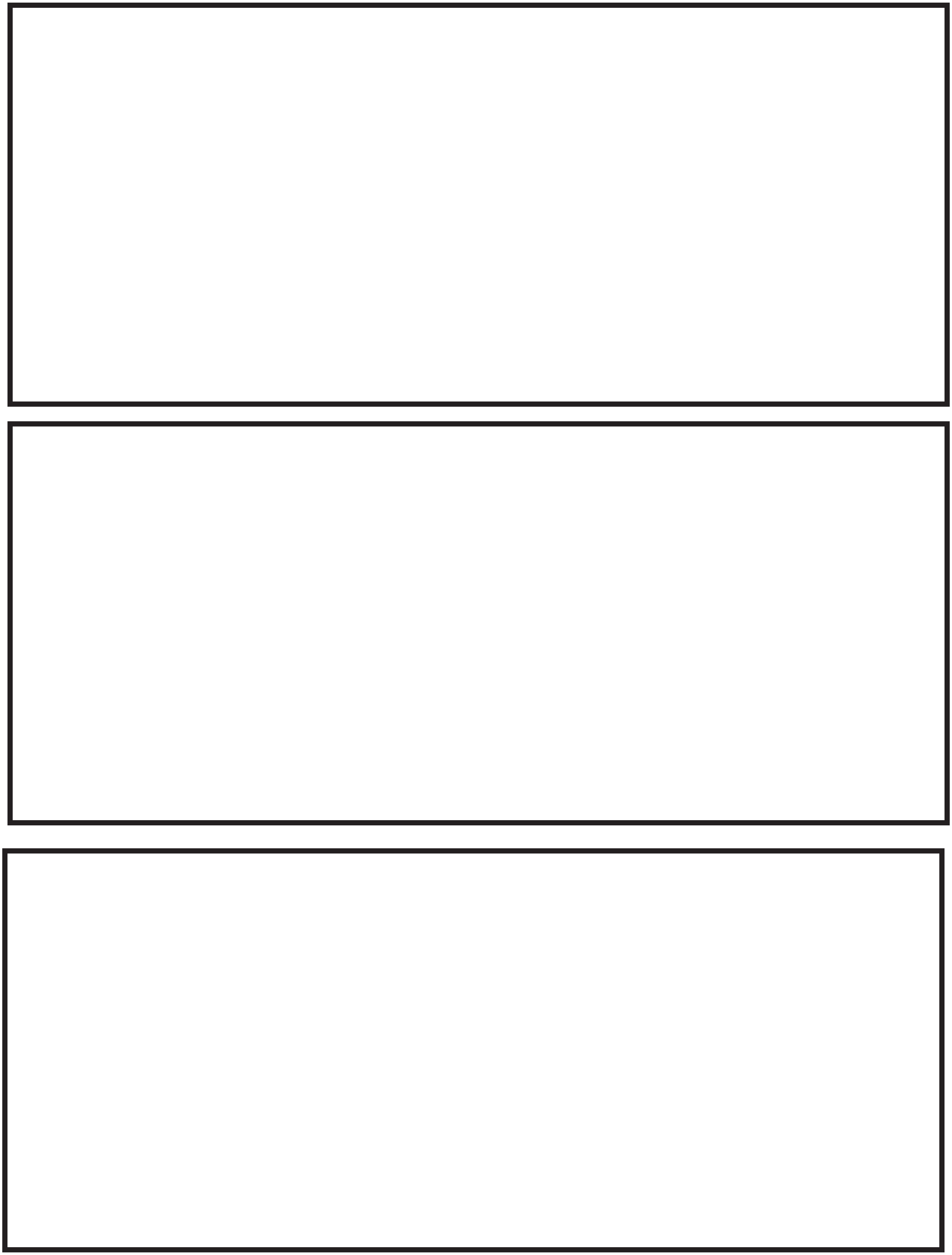
Wheat and soybeans produced in Oklahoma and surrounding states are destined for foreign countries and shipped by barge to serve an important import market. Barges carry grain down the Arkansas to the Mississippi River and on to the Port of South Louisiana. There the grain is stored in grain elevators and loaded onto ships to be exported to countries around the world.







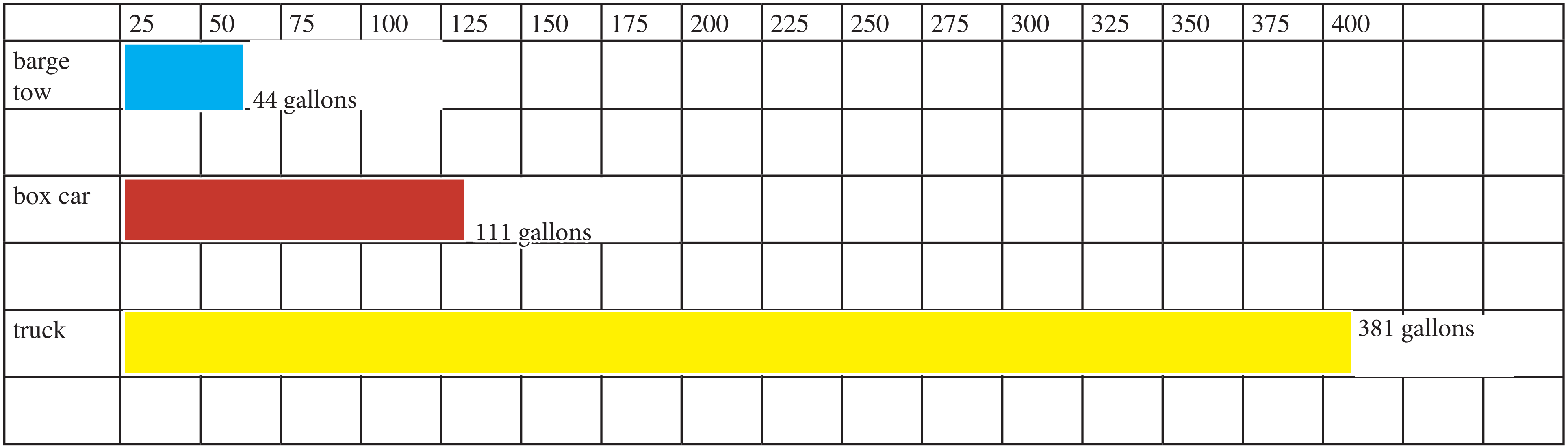




Name____

Trains, Trucks and Barges

Fuel Consumption to move 22,500 tons the distance of one mile



1. How many gallons of fuel does it take to move one barge tow of 22,500 tons the distance of one mile?____________gallons

2. How many gallons of fuel does it take to move 200 rail cars holding 22,500 tons the distance of one mile?____________gallons

3. How many gallons of fuel does it take to move 870 trucks holding 22,500 tons the distance of one mile?____________gallons

4. How many barge tows of 22,500 tons could be moved for the same fuel as the 200 rail cards? __________ barge tows (sets of 15 barges)
5. How many tons is that?_______________ tons

6. How many barge tows of 22,500 tons could be moved for the same amount of fuel as the 870 trucks? _________ barge tows (sets of 15 bages)

7. How many tons is that?_____________ tons

8. Which do you think is the most economical way of transporting agricultural commodities?____

9. Why?____

How Does a Lock Work?

The McClellan-Kerr Arkansas River Navigation System (MKARNS) is 445 river miles long. It includes 18 locks and dams that create a staircase from the Mississippi River up to Catoosa. The five Oklahoma locks and dams are the Newt Graham, Chouteau, Webbers Falls, Robert S. Kerr, and W. D. Mayo. Seven upstream reservoirs reinforce the locks and dams. These are Keystone, Oologah, Eufaula, Tenkiller Ferry, Lake O' The Cherokees, Hudson, and Fort Gibson. The Corps of Engineers works to maintain a minimum nine-foot channel depth, which makes it navigable for barge traffic.

Locks and dams help boats get "up" or "down" the river. The lock and dam system works like filling and draining a bunch of bathtubs. The system features a series of underground tunnels equipped with filling and emptying valves. Before a boat enters the lock, the lock is filled with water moving through an underground tunnel. The water fills the lock, the upper gates are opened, and the boat enters. Once inside, the upper gates are closed, and the emptying valves are opened. The water slowly drains inside the lock, lowering the boat "down a step." The lower gates are opened and the boat leaves the lock to continue down river.

The lock could also be compared an elevator that carries a vessel up or down from one pool to the next. The lock has massive fixed concrete sides and large movable metal gates at each end. The gates are closed to create the equivalent of an elevator car which carries the vessel up or down, using the water enclosed in the lock.

- To move up the waterway from a lower elevation pool to a higher one, a vessel enters the lock chamber at the lower level with the upstream gate closed. The downstream gate closes behind the vessel after it has entered the lock.
- To raise the level of the water in the lock, and the vessel with it, valves are open to allow the water from the upper pool to flow by gravity into the lock until it fills the lock to the same level as the upper pool. The upstream gate is then opened, and the vessel moves out into the upper pool.
- To move a vessel from a higher elevation pool to a lower one, the procedure is reversed. With the downstream gate closed, the vessel moves into the lock chamber filled to the upper pool level, the upstream gate is closed behind the vessel, the water is permitted to drain out of the lock through valves, and the vessel is lowered with the level of the water. When the level of water in the lock reaches that of the lower pool, the downstream miter gate is opened to allow the vessel to move out into the pool.

No pumps are used to fill or empty a lock; the water simply flows by gravity. It takes about 15 minutes to fill or empty a lock chamber.

Conduct the experiment below to demonstrate how a lock works.

Materials

- clay
- graph paper
- grease pencil or permanent marker
- half-pint milk carton
- dish pan, cat litter box (or similarly sized container)
- ruler
- scissors
- small boat (made from 1x1cm styrofoam)
- water

1. Using the scissors, cut the top off your milk carton.
2. Working with one side of the carton, cut a 3 x 3 cm three-sided flap along the bottom edge of the carton. Leave the right side uncut to serve as the hinge and fold that side back. This is your gate.
3. Turn the carton to the opposite side. This time cut a 3 x 3 cm gate along the top edge, leaving one side uncut to serve as the hinge. Fold that side back. You should now have two gates on opposite sides of the milk carton, one at the top edge and one at the bottom edge.
4. Line the cut edges of the gates with clay. Seal both gates closed. Fill your carton with water to test for leakage. Add more clay if the gates leak. Empty the carton. This is your lock with gates.
5. On a third side, use scissors to poke three holes, one centimeter from the top of the carton. Plug them with clay. Fill it with water and test for leakage again. Empty the carton. These holes are the filling valves.
6. Create a boat from a walnut shell, cork, or another material that floats.
7. Fill the pan with water up to 2 cm from the brim of the pan. The pan will serve as the river pool where the boats pass. (At an actual lock and dam site, you would have two pools of water—an upper pool and a lower pool with a dam holding the water in the upper pool from flowing into the lower pool.)
8. Place your lock into the river and weigh it down with pennies or a rock until it rests on the bottom of the river.

LOCKING YOUR BOAT THROUGH

1. Determine the volume of water in the river pool in cubic centimeters (cc). volume = length x width x depth.
2. Before placing the lock in the river pool, determine the maximum volume your lock chamber will hold.
3. Fill the lock chamber to the top of the lower gate. Measure its volume at this level.
4. Mark the waterline on the inside of the chamber with the letter “A.”
5. Place the boat into the lock and place the lock in the middle of the river pool. The top of the lock chamber should be 1 cm above the water level in the pool (you may need to add or remove water). Make sure water from the pool does not enter the lock.
6. Look at the boat. This is how a boat entering from the lower level pool (heading upriver) would appear in the lock chamber.
7. Simulate how the water level rises to bring the boat up even with the water level in the pool. Gradually open the three plugs along the top of the lock chamber.
8. Watch the boat rise in the chamber. When the water stops rising, mark the waterline height on the inside of the lock with the letter “B.”
9. Measure the volume of water in the lock chamber.
10. Open your upper gate and allow the boat to move out into the pan. This simulates the boat passing through the lock to the higher elevation.

Name______________________________

How Does a Lock Work?

Data

Volume in pan _____________cc

Total volume in lock _____________cc

Volume in lock at the lower gate _____________cc

Volume in lock at the upper gate _____________cc

Difference in depth of water from A to B ____________________cm

Difference in volume of water at upper and lower gates______________________cc

Conclusion A

Write one to three paragraphs explaining how a boat traveling north, up the McClellan Kerr Arkansas River Navigation System, is raised up over a dam to the higher elevation on the other side. Use the data you gathered in your explanation. Include a description of the motion of the boat.

Conclusion B

Write one to three paragraphs explaining your changes in the lock to allow a boat to enter at the higher gate and exit at the lower gate. Use the data you gathered in your explanation. Include a description of the motion of the boat.