

Creativity and Inspiration: Our exhibit, *Aquiforever?*, focuses on water sustainability in the Ogallala (or High Plains) Aquifer. Located under the rich farmlands of the Midwest, the Ogallala stretches 174,000 miles from South Dakota to Texas, supplying clean groundwater to eight states. Without this aquifer, the irrigation and farming techniques that feed most of the United States would be impossible. As the need for water is rising, the aquifer is being drained more quickly, pumping water out eight times faster than nature can refill it. Our exhibit shows the role the aquifer plays in the Midwest while invoking a sense of urgency for visitors regarding water sustainability in the Ogallala and the surrounding areas. If the Ogallala goes dry, the breadbasket of the United States will become barren. We will risk losing 40% of the nation's feedlot beef, 15% of the domestic grain crops and 25% of the cotton crops. Recent water conservation efforts in Kansas and Nebraska have begun to stabilize the upper Ogallala, yet the southern Ogallala has areas that are no longer useful for water mining. Climate change could further stress the Ogallala and accelerate its depletion erasing the stability that has been achieved in upper Ogallala.

The inspiration for our exhibit started out simply- with water. Water is the most important resource on the planet. It is easy to see water as an unlimited mineral resource, with 75% of Earth's surface area covered by oceans. However, water's abundance in some areas is matched by its scarcity elsewhere. Before technology made the water in the Ogallala accessible in the early 20th century, America's breadbasket was the Great American Desert. Without water from the Ogallala, this land could never have been transformed into the farmlands that now feed the nation. It is one of the largest aquifers in the world, yet is invisible until wells are drilled and pumps are installed. Our exhibit brings these unseen factors to life for visitors, showing the relevance of a problem that starts and ends in their own back yards.

One reason our exhibit will continue to remain relevant is because the farms in the Midwest rely so heavily on the Ogallala, particularly in drought years, to support the high volume of food production that depends on the Aquifer. The second reason is the effect of climate change on the water needs of Midwestern crops. The third reason is the economic implications for farmers, towns and companies that rely on the Ogallala for economic prosperity. The fourth reason is the development of genetically modified plants with lower water needs. The last reason is the issue of sustainability. Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their own needs. The way the Ogallala Aquifer is managed as a resource will affect future generations.

The condition of the World's Aquifers should be included in Science on a Sphere to communicate the global nature of water resource issues. By overlaying aquifer depletion rates with the availability of electricity, visitors can see the way increased availability of energy effects farming practices positively in the short term but may harm water resources indefinitely.

Conserving and extending the Ogallala Aquifer's usefulness connects with the STEM engineering concepts as a major global issue that requires possible solutions (qualitative and quantitative) while also connecting to the human factor concepts, showing that human behavior has accelerated the depletion of the Ogallala Aquifer. Our project uses the STEM concepts to show how we can extend the useful life of the Ogallala Aquifer through conservation and technology.

One of the most difficult challenges for us was to make the invisible visible. In other words, we could not take a museum visitor to a farm to see a deep well or to visit the site of a dried-up spring. With technology designed by STEM experts, we can use LCD screens, touch screens and computer modeling to help our visitors 'experience' ways the aquifer is affected. They will be able to see the positive and negative effects of real world decisions. Without these virtual tools, learning about the Ogallala Aquifer depletion would be tedious and boring.

Interactive Experience: The key to our *Aquiforever?* exhibit is the hands-on, interactive components. While not all visitors will deeply explore the science they are experiencing, we hope they will think about the hidden water resources that we depend on for our food and be inspired to learn more.

Walking into the exhibit, guests see the dramatic **Hydrosphere Column**, a vertical tube in the stairwell from the first to the second floor that is a model of how water flows from clouds to the underground aquifer. Guests can make it 'rain' in the Hydrosphere Column. This experience will help visitors understand that rainfall does not refill the aquifer. Precipitation will fall from the 'sky' to the ground where it collects in ponds, runs off to rivers, soaks into the soil or evaporates before reaching the ground. Guests will observe filtration in action: water that seeps through the caliche will percolate through the sediment. Guest can enjoy a 55 degree (F) drink from the **Ogallala Fountain** at the base of the Hydrosphere Column.

The "Inside the Aquifer" Room informs visitors about the Ogallala Aquifer as an invisible resource that affects their daily lives. In this space, visitors can **Dig a Well** into four historical stages of the

Ogallala Aquifer: 1910, 1970, 2010 and 2070. For the 1910 Ogallala, a shallow 'well' fills rapidly as the water seeps from the surrounding sediment. A shallow well in the 1970, 2010 or 2070 Ogallala will be dry. Visitors will use simple augers to dig deeper wells as the water table drops over time. In addition, visitors can play the **Ogallala Adventure Through Time** game that is highlighted in our On-line/Digital programming section that follows.

The "Water Mining" room highlights the technology of water mining. Visitors are reminded that the Great American Plains are semi-arid and learn how electricity and pumping advances made large scale farming possible. Visitors can 'lift' water (from the aquifer on the floor below) with pumps in the **Pump Race**. By putting energy into the pump, visitors will do work on the water column to raise the water through the tube from the 'Ogallala Aquifer' on the first floor (more about that later). The harder the visitor pumps, the higher the stream of water will go. Pumping water that is deeper (simulated by a higher stream) requires more costly deep wells and more costly pumps. The watermill in the room is a reminder of old pumping technology that harnessed wind energy. Pumped water will dramatically fall through the enclosed tube to the floor below. A countdown clock will remind visitors that the Ogallala Aquifer is not an endless water supply; it stresses the urgency of addressing aquifer depletion.

On *Aquiforever*'s lower floor, visitors learn about the unique geology of the Great American Plains. On the floor, a map of the Ogallala Aquifer will overlay a map of the US. The floor will include a spectacular feature: reinforced glass shaped like the **Ogallala with a lighted pool of water under the glass**. Along the walls, visitors will learn how the aquifer filled with snowmelt from the Rockies over millions of years and how the existing caliche restricts refilling. The calcium carbonate and caliche restrict water from seeping down to the water table and recharging the aquifer. Here and throughout all exhibits, visitors can scan QR codes to explore in-depth.

The "**Ogallala Shoot-Out**" is a farming game (virtual or physical or a combination). This game is patterned after the classic shoot-out carnival games where visitors shoot a stream of water at a target to advance it. Visitors can just play for fun, or they can manage their farm to achieve the goal to protect the Ogallala Aquifer by conserving water while maximizing crop production. To begin the game, players will pose for their farmer photo at their game station. This photo will be projected onto the wall above their 'farm'.

Farmers will manage three factors that influence farm productivity: crop, irrigation method, and time of irrigation. Each farmer will have the same amount of virtual water to use for irrigation. A farmer who chooses crops with high water needs (like corn) and irrigates with overhead spray at noon will drain their water supply quickly. A virtual farmer growing sunflowers who irrigates with drip irrigation in the early morning will conserve water and produce a higher crop yield. Farmer's progress is projected on an overhead screen. The screen will report individual results with the farmer's picture. The highest scoring farmers will join the **Ogallala Conservationist Hall of Fame** as their photos scroll overhead.

Digital Online Programming: While mobile exhibits are constrained by schedule and location, our virtual app can reach everyone and can be accessed at any time. In the game, players will utilize water and manage its consumption. Players will choose from multiple options as they work through a "choose your own adventure" format, and watch how their choices affect the aquifer. A player's first choice will be to whether to act as a producer, consumer, or manufacturer. The "**Ogallala Adventure Through Time**" game will show the relationship between these three and the Ogallala Aquifer over time. Next, players choose what time period in history to enter: 1910, 1970, 2010 or 2070. The game will be available as a phone app, on the Science City website, and within the "Inside the Aquifer" room of our exhibit on tablets.

Food producers in the game will include family farmers and corporate farms. Food consumers will be buffalo, Native Americans, a Midwestern family, and a third world country supported by America's food output. Food manufacturers will be beef producers, an American cereal company, and an organic, self-sustainable agriculture farmer. The following are example playthroughs in which the player's choices changed the outcome they saw:

Kristen's first grade class went to Science City. After the class visit, her teacher assigned the "Ogallala Adventure Through Time" (OATT) game to Kristen as homework. Her teacher told her to play the game as a consumer, so she thought being a buffalo in 1970 would be fun. Kristen learned her buffalo had been pushed out of its grassland habitat onto parklands (like a zoo animal). To find out if her Buffalo could return to its native grasslands, Kristen played again in 2070 and learned buffaloes roamed the grasslands that returned to much of the Midwest.

Jarrel, a 13 year old from Scott City, also went to Science City with his scout troop and decided to download the OATT app for his phone to play on his ride home. He chose to play as a Midwestern

farmer in 2070. He learned his farm could not rely on the Ogallala Aquifer. His farm raised a genetically modified grain with lower water requirements. The seed was so expensive that his costs were too high to make a living. Farmer Jarrel sold his farm and moved to Pasadena since he was tired of the stress and low income.

Teenager Maria played as an executive of a corporate farm in 2010. The farm was doing well so Maria bought out more local farms. She financed drilling deeper wells that raised crop costs and lowered her company's profits. Maria made a daring decision to use sustainable farming practices that lowered yields for a few years but ultimately saved her company. She became company president and won awards from Conservation groups for her great work.

Constructability: *Aquiforever?* replaces the space of the already existing Space Experience. The exhibit will extend to the floor below to reinforce the idea that aquifers are hidden beneath our feet. Part of the lower floor will be constructed of glass in the shape of the Ogallala Aquifer. A lighted water pool beneath glass will represent the aquifer. Two two-story, clear cylinders will become the focal points of the exhibit. One cylinder is the Pumping Race; the other is the Hydrology Column. Guests will manually pump the water on the second floor, and others will watch what happens to the water through the transparent cylinder on the first floor. The pumps will be calibrated to prevent an over-zealous visitor from hitting the ceiling with a water stream.

The Hydrology Column lets visitors make it 'rain' to begin the hydrology cycle. Most water will be channeled as run-off, showing that rainfall does not significantly refill the aquifer. At the base of the column, a water fountain will appear to deliver water from the aquifer, but will actually use city water that is cooled to the temperature of water coming directly from the Ogallala. Other supplementary exhibits offer guests chances to engage in hands-on or intellectual activities based on their interest level. Some of the supplementary exhibits are virtual requiring touch screens and LCD screens, while others are physical representations like the Pump Game. Guest safety, cost and maintenance are the factors that we considered when we selected virtual or physical experiences for guests. One of the advantages of virtual experiences is the reduced physical footprint for the activity over a similar physical experience. Ample space increases guest safety. There will also be mats in water play areas to reduce the risk of falls on slippery flooring. For the interactive games that include water, limiting the 'aim' of visitors will control the water flow. The mats will reduce the risk of a slip or fall on the glass caused by water. Finally, the cylinders and games will not have sharp corners, taking away possibility of a child running or falling onto a spearing point. In addition, exhibits will include step stools or ledges that will accommodate the heights of smaller children.

Student Involvement: Sophomores, juniors, and seniors combined to research and design *Aquiforever?* on our own time after school. Our diverse team includes students that excel in Science Olympiad, music programs, theater, newspaper, creative writing club, scholar bowl, athletics, broadcasting, and the robotics club. With assistance from mentors and teachers, our ideas eventually became *Aquiforever?*.

Our school does not offer an Earth or Physical Science course so this project gave our team the chance to learn topics that we were interested in. We learned about the geosphere and hydrosphere. We learned that the technological advances of the 1900's made the Midwest a productive farming region. The availability of electricity and electric pumps changed everything. When farmers began pumping water from the Ogallala, the word 'sustainability' was not used. We wonder what decision we are making today that will become the sustainability issues of the future.

We had many ideas – good and bad. Our team considered building a water wheel to demonstrate how water can be used to generate electricity. However, this idea deviated from aquifer sustainability and did not support a STEM concept. Another idea we rejected was a display of severe weather and how it impacted crop growth. Again, this didn't relate to the aquifer, which we wanted to be our focus. The last exhibit idea we rejected showed the entire water cycle and the effects of climate change. Although climate change and aquifer depletion are linked to sustainability, we were unsure that we could effectively present both ideas within the word limits of the report.

To design our idea, we relied heavily on electronic resources after whiteboarding our ideas. With Sketch-Up, we created and edited our design in a 3-D format. We edited our design repeatedly, to the distaste of our Sketchup designer. Microsoft PowerPoint helped us create labeled JPEGs for our attached drawing and iMovie.

Our intellectual resources included interviews with industry experts, our prior knowledge, extensive on-line research (hindered by the government shutdown when USGS websites were off-line), a Science City visit and "Ogallala Blue" by William Ashworth. Our mentor was vital by helping us know our

audience and present our ideas clearly. Other industry experts helped us understand the aquifer and concepts of water depletion. William Ashworth's novel enlightened us on aquifers and their rapidly dwindling water supply.

Visitors to *Aquiforever?* can see the potential for STEM careers in hydrology, geology, engineering, plant genetics, meteorology, system modeling, economics, scientific journalism, and emerging careers that do not exist at this time.

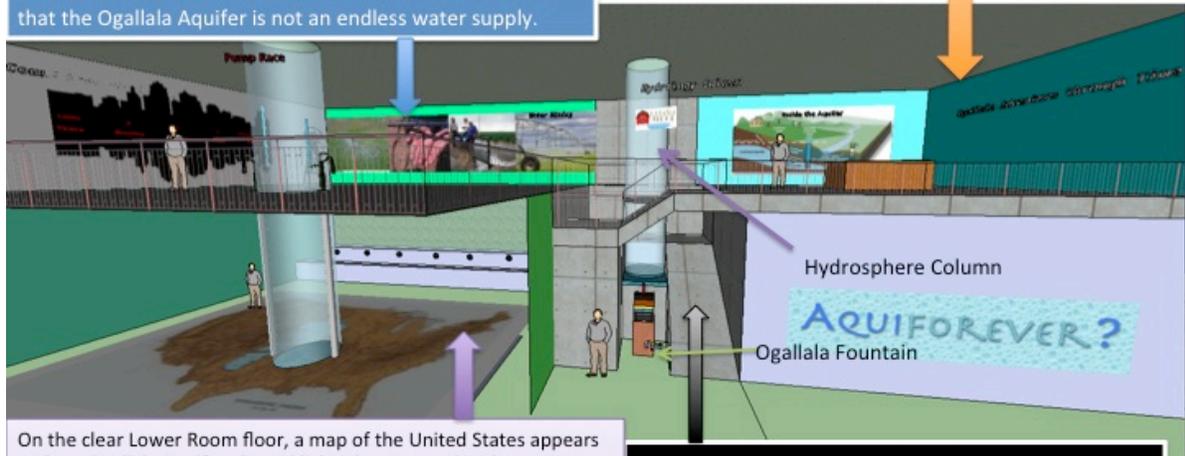
Aquiforever? What ya gonna do when the well runs dry?

Material List:

Material/Item	Price/Unit	Units	Total Cost	Vendor
Reinforced Glass flooring (9" by 12" sheet)	\$9.24	2500	\$23,100.00	Newegg.com
Cooled Water Fountain	\$485.00	1	\$485.00	Global Industrial
Plumbing	\$10,000.00	1	\$10,000.00	Plumbing contractor
Ogallala pool with lighting	\$30,000.00	1	\$30,000.00	Pool contractor
Water Pumps	\$549.99	2	\$1,099.98	Flojak
Digital Clock	\$389.00	1	\$389.00	BIGTIMECLOCKS
Water Carnival Game	\$35,475.00	1	\$35,475.00	BMIGaming.com
Paint per Gallon: Upper Level (60' by 40')	\$30.00	12	\$360.00	Home Depot
Primer: Upper Level	\$80.00	7	\$560.00	Home Depot
Paint per Gallon: Lower Level (23' by 21')	\$30.00	2	\$60.00	Home Depot
Primer: Lower Level	\$80.00	3	\$240.00	Home Depot
Paint Tape	\$5.49	17	\$93.33	Staples
Artificial Grass (3' by 11')	\$129.00	1	\$129.00	Lowes
Artificial Soil	\$3.99	10	\$39.90	Ebay
Clear tubes (diameter 6 feet, height 30 feet)	\$6,000.00	2	\$12,000.00	Private Fabricator
LED Screens	\$1,254.00	12	\$15,048.00	NFM
Dig a well pits	\$1,800.00	4	\$7,200.00	Private contractor
Ogallala Shootout programming	\$20,000.00	1	\$20,000.00	Private contractor
Ogallala Adventure Through Time programming	\$30,000.00	1	\$30,000.00	Private contractor
Water proof mats	\$150.00	6	\$900.00	North Supply
Rocks	\$750.00	1	\$750.00	Alibaba
Signage	\$50,000.00	1	\$50,000.00	Private contractor
Recirculation Pump	\$466.27	1	\$466.27	PlumbingSupply
Total			\$238,395.48	

This section, the Water Mining Room, highlights the technology of water mining. Visitors can 'lift' water from the Aquifer on the floor below by playing the Pump Game. Pumped water will fall through the enclosed tube to the floor below. Visitors will learn how electricity and pumping advances made farming possible on the semi-arid Great Plains. A countdown clock on the wall will remind visitors that the Ogallala Aquifer is not an endless water supply.

This section will remind visitors that water is essential to all life by engaging them in the historical benefits of increased food production. Visitors can play the Ogallala Adventure Through Time game.



On the clear Lower Room floor, a map of the United States appears with an Ogallala Aquifer-shaped lighted water pool in the center. Visitors will engage with the exhibit by playing the Ogallala Shootout game shown across the back wall. Visitors will begin the game by having their picture taken. They will then select a crop to grow, the pumping rate, and the irrigation type. These choices will determine how fast their finite water supply lasts based on the water flow rate. This virtual game is patterned after a popular carnival water. Players who manage their water resources best will have their pictures displayed in the Ogallala Conservationist Hall of Fame.

The Hydrosphere Column shows the waters presence on the surface and its movement through the layers of the ground. Visitors can 'make it rain' on the surface and see that while the pond fills, most of the water runs off. At the Ogallala Fountain at the base of the column, visitors can enjoy a drink of water as cold as what comes directly from the aquifer.

Note: The Ogallala Shootout is priced as both a virtual and a carnival style game. There are benefits to each format. Ideally, an electronically controlled carnival style game would be fun and appealing for Science City guests. A virtual experience could be made available to go with the other on-line game, the Ogallala Adventure Through Time game.