Water Works

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Water, you can drive over it, boat on it and swim under it. It sustains all life. It can be both calming and terrifying. But it is always beautiful to watch. Turn on a faucet and out comes fresh drinkable water, all you want. It is always there. As a result water has become a victim of indifference. We exploit it in the most extravagant ways.

But that is the past. The future will be different. If we don't change our relationship with water, water will take its well-deserved revenge.

Our story will float though a short history of man's relationship with water.

There was a spiritual relationship with water: we honored it - Water gave us pleasure and was a life giving force to be respected. It had profound sacred qualities; it evoked serenity, harmony and peaceful existence.

As populations grew and more people lived in cities, we learned how to move and manage water. We perfected structures that could transport water. Water was available to suit our needs.

Then we learned of the power of condensed water, steam. Steam replaced all other sources of energy. Societies became larger and more complex. We needed new water resources to keep up and increase human production. We learned to dominate this water, to bend it to do our will. Water was there to serve us.

Today, we need to form a new relationship with water. We must protect it and preserve it. If we continue to mistreat our water, a cataclysm looms on every side.

Mother Nature, like all good mothers, is a bit extravagant and overindulgent to us, her children. When it comes to water, we have a super abundance. But only 3% of the world's water is fresh water

Of the world's fresh water 2/3rd of it is locked in glaciers or permanent snow. Almost 1/3 of our fresh water is groundwater stored in wells or aquifers. Only small fraction the world's water is easily available to us in lakes, wetlands, rivers, plants and atmosphere.

Each year, 39 inches of rainfall covers the planet. A majority of that water evaporates or creates humidity. Most of the rest ends up in streams and rivers and ultimately the oceans. Today, we use only about 6.5% of our annual rainwater.

This paper outlines works of water and to determine who is the master and who is the slave.

Part One – Egypt and water reverence

He was essentially naked. His job demanded that the young slave wear as little as possible. He was an attendant to one of the Pharos's ministers of grain, a powerful position in 1250 BC. This minister managed the production of grain on a vast estate near the city of Luxor.

This slave, Jesephite, was a Greek. He was sold to his master in exchange for Egyptian beer. His job during this part of the year was measuring the depth of the Nile. His role was to constantly report to the minister the changing depths of the river during the flooding

season, June to September. He worked out of a canoe made of bundles of papyrus reeds lashed together.

The flooding of the Nile was an annual event given by the gods to sustain its people. The flooding was vital to the production of grain. At a certain point in the flooding the water would reach the irrigation canals which were opened to receive the water and store it for the farming season. Flooding also dislodged the stones indicating property lines. Jesephite needed to keep those stones in place.

The flooding of the Nile was the main contributor to ancient Egypt's agricultural wealth, each summer it deposited nutrient-rich silt onto the river's flood plain. Such fertile land fostered the stable cultivation of barley and wheat allowing people to move to a society that could store and rely on grain. This allowed them to abandon nomadic lifestyles and remain in the same place year after year allowing them the opportunity to develop a more complex civilization.

Jesephite floated along the bank with his measuring rod. The sun warmed his back. The soil beneath him was rich and wet. The topsoil of the Nile basin could measure up to 70 feet. The silt that enriched the soil gathered in the Nile during its journey from the mountains and the jungles. The monsoons from the Indian Ocean filled the river with water. The river silt was a combination of minerals from the mountains and nutrients from the jungles. Unlike other places, the Nile deposited the nutrients and minerals on top of the soil making it unnecessary to deep plow. The soil was easy to work. Eygpt was a farmer's utopia.

Jesephite measured the water depth every 500 feet or so. The gods were kind. The volume of water in this year's flooding promised an abundant grain harvest. A good flood killed the vermin, it warded off the swarms of locusts and it prevented the South winds from stealing off the harvest.

All the cities and towns were laid out along the Nile and therefore easily accessible by boat. Boating on the Nile provided the perfect means of transport between these cities and towns. When boats were traveling north on the Nile, they would be going with the current. When the ships were traveling south, they had the wind blowing in their direction and could use a sail.

Boats and ships were imbedded in the fabric of Ancient Egyptian beliefs and ideologies. A poor man was symbolized as having no boat. And when a Pharaoh was entombed, a small boat or model of a boat would be buried with him so that he might "pass to the other side", that the cold waters of the Nile would bear him, the symbol of Egypt, in death as they had in life.

Joy and happiness is also intimately linked with the Nile River. Here is a description of King Sneferu's boating party:

His majesty said to him: 'I have gone through all the rooms of the palace in search of relaxation and found none.' His minister said: 'May your majesty proceed to the lake of the palace. Fill a boat with all the beautiful girls of your palace. Your majesty's heart will be refreshed by seeing them row, a rowing up and down. As you observe the nesting places of your lake, as you observe its beautiful fields and shores, your heart will be refreshed by it.'

Said his majesty: 'Indeed, I shall go boating! Let there be brought to me twenty oars of ebony plated with gold, their handles of sandalwood plated with electrum. Let there be brought to me twenty women with shapeliest bodies, breasts, and braids, who have not yet given birth. Also let there be brought to me twenty nets and give these nets to these women in place of their clothes!' All was done as his majesty commanded.

During the time of the flooding, the Pharaoh employed the farmers to move large blocks of stone by water for architectural works. There were great distances between the quarries and construction sites. The Egyptians were masters of sailing strong and reliable river vessels, with shallow draft and large capacity. These were the boats required to move the construction stones for the pyramids and temples.

During this flooding season, the farmers from Jesephite's estate were engaged in the transportation and placement of the two eighty foot obelisks that would decorate the new temple of Luxor being built by Ramses II, The obelisks were granite cut from a stone quarry miles south of Luxor. Each weighed 227 tons. The obelisks were then hauled to the river on rollers. A canal was dug and the obelisk was supported on beams above the water. A barge filled with heavy stones was floated into position under the obelisk and when the stones were removed, the barge rose up, lifting the obelisk.

The massive barge was rowed down the Nile to the Luxor temple site. The barge was towed by a flotilla of boats, with a total of 900 men rowing.

Jesiphite's mind wandered as he floated along. He thought about the upcoming festival to Amon, a god of fertility. All of the citizens of the region would come to the celebration. It was really a celebration of the Nile. It was said that Pharaoh himself would spill his own seed into the Nile to symbolize his power of creation.

By celebrating the gods and the changing of the seasons, Egyptians showed their love and appreciation for the great gods while ensuring that they themselves would be rewarded and maintain power over their land.

Bread and Beer would be plentiful. He smiled thinking about the day's festivities and the evening's delights

Part Two – Rome and water management

Romans loved water and its flow. The Romans thought of water movement on a grand scale and managed it through the construction of cisterns, wells and aqueducts.

Oman, the Roman, was contemplating a problem. He was lost in thought as he soaked in the heated waters of the Baths of Trajan. After bathing and then sweating in the gym he would use the Bath's library to help resolve the problem.

Oman liked this particular bath. He often worked out issues while soaking alone or with his engineering friends in the afternoon. The Baths were inexpensive and open to all the freeman of Rome.

Oman was one of a group of engineers working out the mathematics of a new aqueduct for City. The Roman engineers and surveyors were masters of water manipulation and management. They were responsible for moving fresh water around the empire with aqueducts.

Three engineering advances made the Roman aqueduct possible, the siphon, the arch and concrete.

Construction on this new aqueduct stopped because it needed to cross a wide valley. Oman's job was to work out the calculations to construct a siphon to get the water across the valley. A holding tank for the water was built on one side of the Aqueduct; this water would then be channeled into a series of pipes carrying the water down the side of the hill and across the bottom.

If the calculations were correct, the force of gravity would then shoot the water up the hill into a receiving tank where it would then resume its journey. Oman was familiar with this work. He spent most of his life managing the movement of water. The system needed to be water tight so that the siphon could be started. Oman's design was important so that the water's force did not break the pipes.

The development of the Arch was important to water management. When water needed to cross an area without level terrain, say a valley, an arcade of arches provided the support needed to sustain the weight of the water flow over the valley. Aqueducts required a constant, gradual slope so that water could continue to flow. This would have been impossible without arches to elevate and support the aqueducts.

The third element was the discovery and use of volcanic sand called pozzolana. This sand mixed with water produced a concrete of remarkable strength and setting power. This mortar revolutionized Roman construction. Now the Romans could build much bigger arches and vaults and could stack them on top of one another. The Romans were now able to construct long high aqueducts needed to move water from place to place.

An example Aqueduct engineering is the Aqua Claudia, it supplied Rome with water from a lake 43 miles away. The source of the water was just 820 feet higher than Rome itself. This meant that the engineers and surveyors had to design the Aqua Claudia to gradually drop no more than 3 feet in height for every 920 feet of its 43 mile length.

Aqueduct water travel would end on the top of one of the hills of Rome. There the Roman engineers built large tanks where the water flow decelerated and, ideally settled Drinking water from the tanks

passed through a circle of clay jars packed with charcoal and sand grilles to filter the water.

At its height, the City of Rome had nine aqueducts, delivering 280,000,000 million gallons of water a day to the City, all of it transported by gravity.

It is impossible to imagine Rome, without its aqueducts as Roman water from the river or wells of the city were polluted and undrinkable.

The real priority for building the aqueducts was to bring water to Rome's public baths. The Romans made bathing a near-obsession. Bathing was a daily ritual for cleaning but also a means of socializing. Public baths provided pools of different temperatures. Major baths were also places of entertainment.

The Roman baths were a cacophony, Seneca, the Philosopher wrote this to his nephew:

My dear Lucilius,

If you want to study, quiet is not nearly as necessary as you might think. Here I am, surrounded by all kinds of noise (my lodgings overlook a bath-house). Conjure up in your imagination all the sounds that make one hate one's ears. I hear the grunts of musclemen exercising and jerking those heavy weights around; they are working hard, or pretending to. I hear their sharp hissing when they release their pent breath. If there happens to be a lazy fellow content with a simple massage I hear the slap of hand on a shoulder.

If a ball-player comes up and starts calling out his score, I'm done for.

Add to this the racket of a cocky bastard, a thief caught in the act, and a fellow who likes the sound of his own voice in the bath, plus those who plunge into the pool with a huge splash of water. Besides those who just have loud voices, imagine the skinny armpit-hair plucker whose cries are shrill so as to draw people's attention and never stop except when he's doing his job and making someone else shriek for him.

Now add the mingled cries of the drink peddler and the sellers of sausages, pastries, and hot fare, each hawking his own wares

The aqueducts also supplied the fountains of Rome. The fountains in the City cooled the air and were a source of water for the citizens' personal use. Ancient Rome had 39 monumental fountains and hundreds of public basins.

The Romans also developed a sewer system, which emptied waste water from the public latrines and laundries into the Tiber River. A typical Roman latrine served 12-60 people at one time. Some of the latrines were elaborate and could be amusing.

Cleaning was done with a sponge on a stick passed from one citizen to the next. However, you could hire a slave to do the dirty work. The latrines were basically dank holes leading to sewer channels. From these underground channels sometimes emerged biting creatures or flames because of methane gas buildup. Bites on the bits from some sewer dweller or naked flames on a naked ass did nothing to create a sense of wellbeing or comfort.

Now, we leave Rome. But it's important to note the management and movement of water remained virtually unchanged for the next 1300 years. And then man's relationship with water completely changed.

Part three – America/Dominance

Only two hundred and fifty years ago, a group of inventions revolutionized our energy supply. We were freed from a reliance on human and animal muscle, gravity and wind to produce energy. We harnessed this new energy source for agriculture and manufacturing and our approach to Mother Earth and her natural resources changed. We became aware of the power of steam to drive our machines.

The year is 1845. The place, an engine shed in Pennsylvania. Jack's face is covered in grime and soot. His shirt is off and his chest glistens from the heat and blackness of the engine house. He is the chief engineer on the Lehigh Valley Railroad in Pennsylvania. The week has not gone well. Two engines broke down on the tracks between the coal mines of Pennsylvania. He and his men needed to repair the engines and get them back on the road. Jack's company controlled the coal delivery across this part of Pennsylvania. Coal was vital to the factories. Maintenance of the train engines were Jack's responsibility.

He was an immigrant to America from France. He was from a family of engineers. Jack's father worked in the English engineering shop of James Watt and Matthew Boulton. There he learned about the steam engine and its power as a new source of energy to drive factory machines, locomotives and ships. Jack and his brother learned the trade from their father. Jack moved to America and worked on locomotives and his brother moved to France to build steam powered boats.

The Greeks first discovered that steam could be used as energy to turn a machine. For some reason no functional use of that energy was employed for another 2000 years. Maybe it would have been longer if England had not run out of wood. The English glass industry required high temperature furnaces and used vast amounts of wood. Forests in England were rapidly disappearing. When Parliament banned the use

of wood for energy, coal became the alternative fuel source to run factories in Britain.

But coal came from mines and as the need for more coal became greater, deeper mines were required. At times these mines filled with water and had to be pumped out. The process of pumping machines driven by animals and wind was too slow. A new process of pumping water was needed.

Coal can be used to heat water to a boiling point which creates steam. Steam pressure can produce a mechanical motion that drives an engine. The first application of this new idea was the development of steam pump to pump water out of the coal mines. It worked and now there was access to deeper mines and more coal. There is a virtual loop here. Steam power was created by heating water with coal. The steam could drive faster and bigger pumps. Faster and bigger pumps allowed for more production of coal.

Immediately, steam power was seen as valuable for other uses. Seasonal fluctuation in water flow did not interfere with steam power. One could only use water power where water ran. Water would disappear in droughts and it froze in the winter. With steam, factories did not have to locate in remote rural areas where water was available but labor was in short supply. Steam power was unlimited in supply.

Now for the first time in two thousand years human per capita production increased. For centuries, the annual production per person changed very little. Put another way, a person living during the time of William Shakespeare lived very much like his counterpart in the time of Homer. They wore similar clothes. The variety and amount of food was the same. And the time it took to produce food and goods was about the same. After 1750, the productivity of each individual improved dramatically.

Man was now in position to actualize the belief that he, as a species, would master the earth. Nature would be man's subordinate. The earth was to yield up its bounty and its secrets.

From the deepest coal mines and oil reserves to the hidden power of the atom, everything was to be man's to command. Swamps and marshes could be drained and diverted. Land could be reclaimed and cultivated. Nature and natural things became objectified. Man had finally triumphed over gravity, wind and water.

The first commercially viable steam engine was built in 1776. But it was James Watt and Matthew Boulton who tailored Watt's version of the steam engine to just about any company or industry that could use it. They also shared their research over vast distances. Sharing of research between countries was a new idea at the time.

France became an innovator in steam power. Joseph Marie Jacquard developed a way to improve mechanical textile looms. He designed a loom in which a series of cards with punched holes created complex textile patterns. The Jaquard power loom's punch card design led to the development of storing computer data and computer programs on punch cards.

Marquis de Jouffroy invented the world's first successful steamboat. He sailed the 43 foot steamboat with duck foot paddles in 1783 near the City of Leon.

In 1828, The French steam ship *Le Sphinx* was built for the French Navy. It was fitted with a steam engine from a British firm. In August 1832, the *Sphinx* sailed to Alexandria, Eygpt to rendezvous with a barge and load one of the two Luxor Obelisks built during the reign of Ramses II, onto that barge and tow it back to France. A French engineer had

bargained with the Viceroy of Eygpt, Muhammad Ali, for the obelisk in exchange for a large clock. The Obelisk was installed in the Place de la Concorde in 1836 and it stands there today.

In the United States, the invention of the Steam Locomotive had the greatest impact on the Country. For the first time in history, goods were transported over land by something other than the muscle of man or animal.

The ability to move people and goods anywhere in the United States resulted in the growth of cities and an expansion of the economy. Steam locomotives were the most reliable and most inexpensive form of transportation. Goods were produced in factories that used steam engines and were then transported by trains powered by steam locomotives.

Man's designed steam machines to replace all other forms of energy. But it came at a cost. In our rush for progress and growth we became blind to our impact on the environment.

In Cincinnati, we can look at our own Mill Creek to see a symbol of man's mastery of natural resources. We know the Mill Creek as a smelly waste laden ribbon of brown water running through a concrete trench. The condition of the creek stands as testimony of man's rush to control nature and wrest its natural ways to his advantage.

Two hundred years ago, the river plain provided rich soils for farming. It provided an abundance and diversity of plants and wildlife. Early families enjoyed swimming and fishing in the Mill Creek, then known as Deer Creek. But in the midst of the Industrial Revolution we became blind to the environmental value of our Mill Creek. The watershed was deforested and lined with slaughter houses and factories. Mills were built for the manufacture of barrels, flour, flax seed oil, and fiber. In

1856, Cincinnati slaughtered 450,000 hogs. Torrents of hog blood and poured into the Mill Creek.

Today the Mill Creek is considered one of the most physically degreaded streams in the United States. In 1997, it was described as "the most endangered urban river in America.

Jack and his crew, worked furiously to get the two steam engines back in working order. These engines were huge and not really efficient. But they were able to pull hundreds of tons of coal to burn in the factories along the Eastern Seaboard. The smoke from the engines and the heat from the engine boilers was intense, but Jack smiled, he didn't mind inhaling the black coal smoke and the sweating in the heat. In fact he enjoyed the smell of burning coal. He knew he was part of the movement that would improve the lives of others.

Part Four - The World and a new relationship with Water

Rain rain
Go away
Come again
Another day

Aaron was exhausted. Now in Paris, he was soaking in the deep tub in his hotel suite in the Place de Concorde. He had been on three continents in the last three weeks showing government ministers how the Israelis were succeeding in conserving water. The popular children's rhyme stayed with him. It summarized much of what needed to change in the world's relationship with water.

Aaron grew up in Israel. It is a country with an arid climate. Yet the country is water sufficient. Indeed, they are able to supply water to their much less organized Palestinian neighbors.

Israel's respect for every drop of water combined with government policy and new technology had made the country water abundant even though most of the country is desert. In Israel, rain is a gift to be preserved. Their success in water management and technology and the sharing of the water is potentially a back channel to peace in the Middle East.

Aaron would tell the assembled ministers that our supposed domination over the natural resource of water has to be rethought so as not to imperil the future of our grandchildren and great grandchildren.

Aaron's address on the subject of water would focus on three topics, government policy regarding how water is used, water efficiency, and the use of water technology.

His address would encourage the government ministers to recognize water as a precious commodity and price it accordingly. Water subsidies have not been helpful in the conservation of water. It's common for citizens to pay only for the water pumping cost to the home.

The real cost of water includes the development of the resource, the infrastructure to transport the water, the testing and treatment of water, the pumping of it to the house and the removal and treatment of sewage.

Real pricing encourages consumers to use what they need, but not more. Economic market forces would encourage water savings and technological innovation.

Aaron would explain that the average middle class person uses 38 gallons of water each day. When you include the water needed to make the food and products that the average person eats and/or uses each day, the amount rises to 898 gallons each day.

Water efficiency saves more money than finding new sources of water. Water savings could be achieved by improving the storage and delivery of water, reducing storm water runoff and replacing leaking municipal water pipes. Water efficiency costs between $450 and $1600 for every million gallons saved. Every new water source costs more. For example desalination costs $15,000 for the same one million gallons.

The water demands of current and future populations have outstripped the available water resources in many countries. But rather than solving the issue, countries have masked the problem by trading in water-intensive food.

Egypt is an example. Egypt imports 60% of its wheat much of it from the United States. It takes large amounts of water to produce wheat. When Egypt imports wheat, they are in reality importing water as they conserved their own water by not growing the wheat themselves.

70% of California's almonds are sold overseas. That makes almonds the State's number one agricultural export. California's almonds use 10% of California's total water supply each year. Each individual almond takes one gallon of water to grow. Alfalfa hay requires 15% of the California's total water supply. These two crops use far more water than all of the indoor water used by California's 39 million residents.

And California farmers export much of the almond crop and alfalfa hay to other countries such as China. The U.S. is exporting water by exporting water thirsty agricultural products to China and countries in Asia.

These international trade policies are delaying a crisis. Imagine if the governments of Egypt or China admitted to their people that their countries were in a water deficit. What if they said that the country's water and food security depends on the international trade policies and the weather patterns of other countries?

One of the world's biggest risks is the depletion of our ground water. Groundwater is that water below earth's surface and is one of the most important sources of water on Earth. Almost 30 percent of our available freshwater is groundwater.

But we are pumping out our aquifers at an alarming rate to serve the water needs of our cities and more importantly the needs of agriculture. Texas gets almost 60 percent of its water from groundwater. Florida, takes 90 percent of its fresh water from groundwater. Ground water pumping is exceeding most aquifers' ability to recharge resulting in aquifer depletion. The land over depleted aquifers becomes unstable and then begins to sink. This is happening in the United States and all over the world.

In addition to over pumping, the quality of water in an aquifer is threatened by saltwater, fertilizer, septic tank discharge, and chemicals such as pesticides or petroleum products. Once an aquifer is contaminated, it's hard to fix.

Aaron would tell the members of the conference that we must alter our approach to agriculture, which uses about 70% of the world's water supply. He would outline two methods Israel developed to solve the issue.

Aaron family pioneered the use of drip irrigation in agriculture to conserve water. 75% of Israel's agricultural fields use drip irrigation. Drip irrigation provides just the right amount of water and water soluble fertilizer at the plant's roots.

In contrast, most American farmers still use ancient flood and spray irrigation techniques. These are systems not all that dissimilar to the flooding techniques of the Egyptians 3000 years ago. Much of the American farming water is lost due to evaporation, wind drift and field run off. More frequent algae blooms in our fresh water lakes and rivers are the direct result of this primitive agricultural irrigation waste.

Technology also offers a new source of water for agriculture. Israeli farmers are using treated sewage water as a resource. 85% of that country's sewage is collected, treated and the water is then reused for agriculture. It's hard to believe that the United State collects and treats the majority of its sewage, and then we basically dump this water into our rivers, lakes and oceans. Less than 8% of US treated sewage is reused.

Is desalinization the answer to the world's water shortage; probably not? The process of converting salt water to fresh water consumes lots of expensive energy. Today desalinization is confined to countries where money and energy is cheap and abundant. To make desalinization work, several questions need answers. How do you harness cheap energy? How do you pump it to where you need it? What do you do with the brine residue?

In the morning, Aaron left his hotel and walked into the Place de Concorde on his way to his conference. Momentarily, he stared at the great obelisk of Luxor, standing there since 1832. The intricate carvings on the obelisk were slowly disappearing as a result of the water and air

pollution in Paris. The disappearance of the carvings was worse in the last 170 years than in the 3000 years the obelisk stood at the temple of Luxor. He wondered if this was a totem of what man was willing to lose if he did not adopt a new relationship with Mother Nature and her resources. He shook his head and said a prayer that it would not be so.