Solve the World Water Crisis

by Benjamin Deniston

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Today's world water crises will be solved by recognizing mankind's *obligation* to act as the caretaker of Earth—to be a creative force, continuously improving the conditions across the planet (and beyond). As Lyndon LaRouche has emphasized, this is the scientific conclusion required by the work of the great Russian-Ukrainian scientist Vladimir Vernadsky, who demonstrated that human society expresses a capability absent in all lower forms of animal life, a capability more powerful than the cumulation of the actions of animal and plant life (the biosphere)—the force of scientific and cultural thought (the noösphere). Whether the modern-day environmentalist likes this or not, the scientific reality is that mankind has been born into a responsibility to continuously re-shape and improve the surface of the planet. To deny this is to deny the existence of humanity.

This is the principle at issue in the current global water crisis. Basic progress and development have been thwarted in recent decades, to the point where 4 billion people, more than half the world's population, do not have safe, reliable supplies of water for even drinking and sanitation. Food production is threatened. The industrial base is far below what is required to produce for the future. Sickness and death are occurring, for lack of water.

How can this be tolerated when more than 70% of the Earth's surface is covered in water? To put this in a conceptual perspective, if the entire world population was able to use water at the same per capita levels of the United States currently, there is one hundred thousand times more water on Earth than would be used in a year by 7 billion people at the current U.S.A. per capita rate.[1] In terms of freshwater, there is approximately three thousand times more freshwater on Earth than would be used by the entire world at this hypothetical rate.[2]

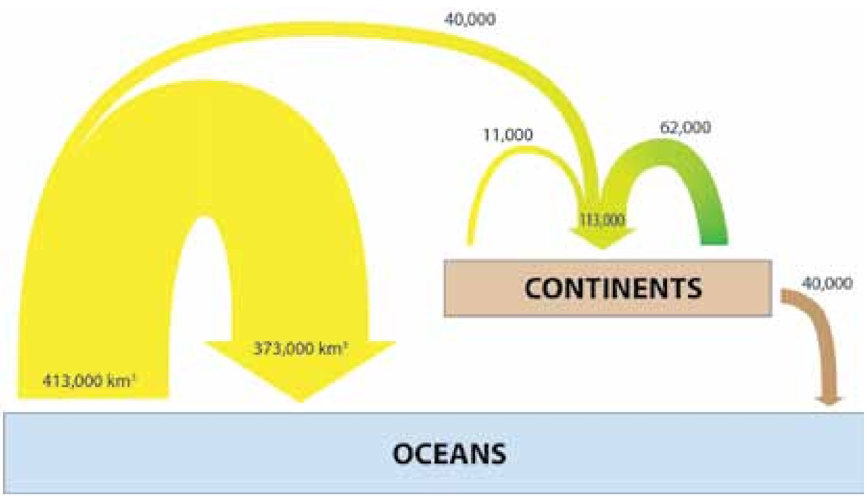
But, water supplies cannot be discussed simply in terms of "use." Water is not a "finite resource" that is only used once (such as coal or natural gas). The global water system has cyclical-type characteristics, with water constantly moving from one state to another state (e.g., liquid oceans, frozen ice caps, and atmospheric vapor) and from participating in one system to another system (e.g., oceans, living matter, and human economic processes). *For this reason, any attempt to address the water needs of billions of people, both now and far into the future, must focus on the management—or creation—of cycles, not "use" per se.*

Throughout the history of life on Earth, including human civilization, thus far, the most important water cycle has been that of ocean evaporation, precipitation over land, and surface flow back into the oceans. This will be referred to as the **terrestrial water cycle** (see **Figure 1**). This is what sustains the entirety of life on land (although plants have increasingly augmented and boosted this cycle), and it has improved life in the oceans (by bringing nutrients from land). Today, it is estimated that the rate of this cycle (measured by annual

1. The current U.S. per capita use is four times the global average. The United States Geological Survey (USGS) and U.S. Department of the Interior report, "Estimated Use of Water in the United States in 2005," provides a total freshwater use which translates to a per capita use of about 160 cubic meters per person per year. This is all direct water use for all aspects of society, including public supply (11% of total use), domestic (1%), irrigation/agriculture (31%), livestock/aquaculture (3%), industrial (4%), mining (1%), and cooling of thermoelectric power plants (49%), but it does not include "hidden" water use such as in the production of foods, industrial goods, and other items that require water for their production that are imported.

2. Estimates of current global water distribution and water flows are taken from the study, "Estimates of the Global Water Budget and Its Annual Cycle Using Observational and Model Data," by Kevin Trenberth et al., from the National Center for Atmospheric Research in Boulder, Colorado; published in the *Journal of Hydrometeorology*, Volume 8, 2007. This does not include the recent discoveries of large aquifers beneath the oceans, and even larger amounts of water in mineral formations deep within the Earth's crust.

FIGURE 1
Global Terrestrial Water Cycle



Benjamin Deniston/EIRNS 2014

new terrestrial precipitation) is 3.5 times higher than the rate that would be required by our hypothetical case of 7 billion people using water at U.S. per capita levels. However, this falls far short of understanding the water availability of the existing global terrestrial water cycle, because water is used many times in the course of one cycle. For example, the same water could cool a thermoelectric power plant, then irrigate a farm, and then go into a sanitation system, getting "used" three times in the course of one cycle. In many circumstances the reuse rate can be even higher.

Therefore, speaking in terms of cycles, the annual terrestrial precipitation can be used to define the **rate of a cycle**, and the amount of use and reuse can be used to define the productivity of a cycle. These measures can be applied to the global cycle, or divided into continental cycles, or further subdivided into individual river basins, and so on (for example, see the box below, "Increasing the Physical Productivity of the North American Water Cycle"). Examining the global water system from this standpoint, it is clear that the water resources are there; what is lacking is the economic development and energy flux density[3] needed to improve the productivity of existing cycles (with purification, sanitation, and related systems), control or expand existing cycles (e.g., with reservoirs and river diversion systems), and create new cycles (with weather modification and desalination systems).

3. See first article in this section.

What Is a Resource?

This becomes a rather basic pedagogy in Mr. LaRouche's science of physical economics. *It is mankind that creates resources.*

The concept of "natural" resources is misleading, if not fraudulent. For mankind, the factor that determines if something is, or is not a "resource" is never simply its "natural" state, but the level of scientific development of a society. Water is simply one excellent example of this principle of humanity.

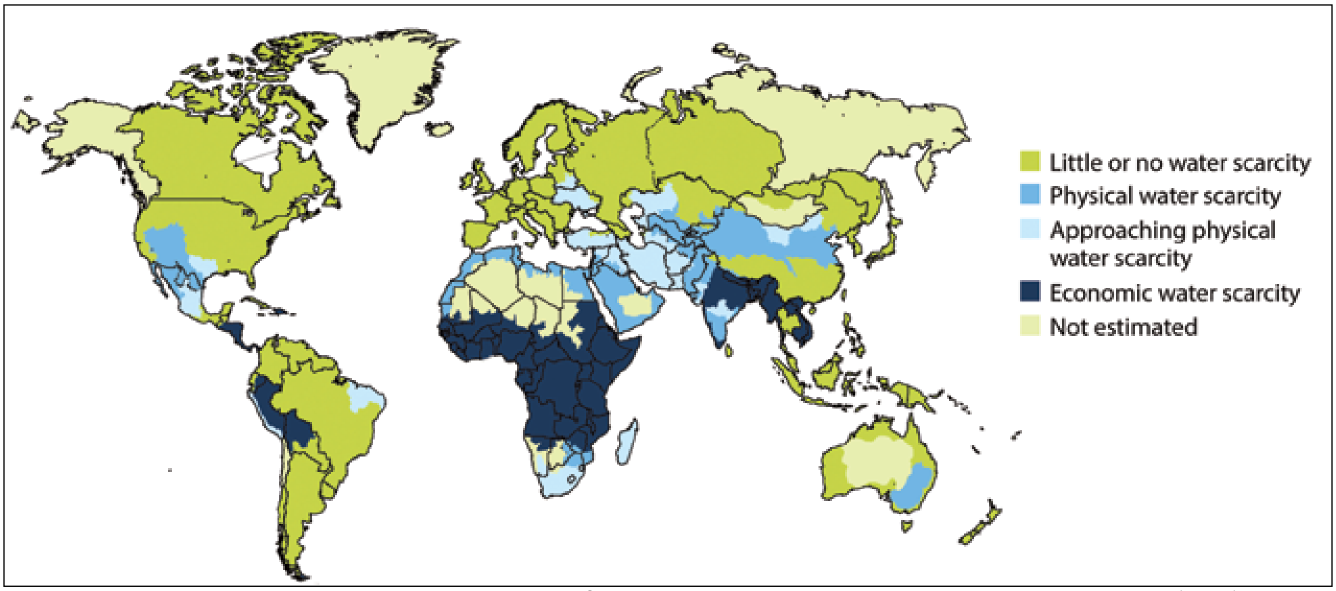
Until recent generations, the freshwater resources available to mankind were limited to the management of the existing regional terrestrial water cycles, including all the rivers, lakes, groundwater, etc., created and maintained by these cycles. While the use and productivity of the existing cycles could (and can) be improved, the size and availability of this resource had largely remained outside of mankind's control—a situation vulnerable to regional climate changes, such as those associated with changing solar activity (as discussed below).

Now, with new technological developments that can be employed en masse on a global scale with the energy flux density provided by a fission and fusion economy, mankind can, for the first time, *look to managing entire continental cycles and even the creation of new cycles through weather modification technologies and desalination systems*. Before investigating the details of these concepts, reflect upon the broader implications.

Until this point, the entire planetary terrestrial water cycle had been solely under the dominion of the Sun, providing all desalination (ocean evaporation) and water vapor inland transport with solar energy. But now, for the first time in the history of Earth, a new power has emerged. Though relatively small in its beginnings, mankind, in line with Vernadsky's understanding, is beginning to overtake the role of the Sun on Earth, through the manipulation of atmospheric moisture flows (with weather modification), the manufacture of freshwater (with desalination), and the distribution of these new sources of freshwater throughout terrestrial systems.

Lyndon LaRouche has emphasized that the solution to the water crisis requires embracing the scientific re-

FIGURE 2
Global Physical and Economic Water Scarcity



Source: World Water Development Report 4, World Water Assessment Programme (WWAP), March 2012

alization of Vernadsky—mankind, wielding the power of scientific thought, is a geological force, responsible for the improvement of the global water system as a whole. For an advancing mankind, the needed water resources exist; it is the effective organization of the powers of human society that has been lacking.

This is the scientific basis governing the following section of this report. First, to properly situate the challenges that need be addressed, the dimensions of the global water crisis are briefly reviewed, with selected examples chosen to illustrate the principled nature of the challenges facing mankind. Then the prospects for the future of a top-down, global approach to the world's water crisis are discussed.

I. Dimensions of the Crisis

The lack of water availability globally can be summarized simply. Of today's total world population, nearly 900 million people do not have safe water to drink and 2.6 billion do not have sanitation systems, for lack of water.[4] When the metric is properly set higher, to include those people without safe and reliable tap water in their homes, the number lacking these arrangements is up to 4 billions. Moreover, for many millions who have had good water—in the Southwest of the United States, for example—their future water security is threatened.

Another dramatic expression of the world water management crisis is seen in the prevalence and increase of waterborne illness. Cholera is a marker disease for lack of basic water management. The number of cases increased 130% worldwide, from 2000 to 2010, according to the World Health Organization (WHO). WHO estimates that every year now, there are 3 to 5 million cholera cases, with 100,000 to 200,000 deaths. This is a conservative guess, given that WHO estimates only 5-10% of cases are officially reported.[5]

A concept-map of the global distribution of the water crisis was featured in the 2012 United Nations World Water Development Report, identifying two aspects to the water crisis: "economic" and "physical" (**Figure 2**).[6] "Economic" refers to locations where the basic infrastructure has not been developed to make use of available water. "Physical" refers to locations where

4. United Nations "World Water Development Report 2014—Water and Energy," page 7.

5. World Health Organization Fact Sheet No. 107; reviewed February 2014.

6. World Water Assessment Programme (WWAP), 2012. The United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk. Paris, UNESCO.

the needs of society have outpaced existing local water supplies.

While Figure 2 serves as a snapshot of the global characteristics and geography of the water crisis, as of this writing the analysis is more than five years old, and conditions in certain regions have gotten worse.

In the following section, on the dimensions of the crisis, four aspects of the global water crisis are examined, starting with a brief focus on insane policies that are unnecessarily accelerating the water crisis and must be ended immediately—hydraulic fracturing and biofuels. Then two aspects of the water crisis are examined—the depletion of ground water stores, followed by the deficiency in or lack of management of surface water supplies. Lastly, we examine the role of changing solar activity, with emphasis on what is known about previous major shifts in regional climate and water patterns associated with the type of solar changes that we may be experiencing in the coming decades.

The already existing depths of the water crisis, seen against the future possibility for solar-driven changes in regional terrestrial water cycles, defines the top-down overview of a single planetary crisis to be addressed in the latter half of this article.

A. Policies Accelerating the Crisis

The combined impact of many factors, such as depletion, physical and economic constraints, and intentional obstruction of infrastructure and technologies, has brought the world to its present point of water availability crisis. Yet, despite this, certain nations are accelerating additional practices making an already bad situation, catastrophic. The most glaring are hydraulic fracturing and biofuels. These policies not only waste water, but they waste water for energy sources that are effectively a net drain on their economies.

Hydraulic Fracturing

The fast-expanding use of water for hydraulic fracturing (fracking) for oil and gas extraction is a direct threat to water availability in certain areas. While the specific water requirements vary per well, depending on the type of shale deposit (e.g., how many times the hole is fracked or what quality of water is used), the practice is clearly detrimental.

In the United States—the world leader in fracking—and Canada, nearly half (47%) of oil and gas wells opened by fracking *are located in areas of high water stress*, including California, North Dakota, and Wyoming in the High Plains and Texas and New Mexico. Drought-stricken Texas leads all states in the number of such wells, with more than 9,000 opened in extremely water-short areas, and another 9,000 in dry-prone locations. Only about 5% of all water used for fracking in these areas has been recycled; that is, 95% is "consumed" and gone. The volume of water consumed in these wells overall in the United States and Canada, over a 2.5 year period, amounted to 367 million m^3 (97 billion gallons). That is an annual rate equivalent to the municipal water use of a city of 1 million people.

While this is already a waste of water occurring in the context of an existing crisis, there is a push to greatly expand this insane policy.

Biofuels

The production of ethanol, biodiesel, and gasohol is underway at levels diverting huge volumes of water for biomass agriculture and processing—a direct loss to food production, as well as a waste of water. World ethanol production for 2014 is expected to reach a record 90 billion liters (23 billion gallons). In the United States, the world leader in ethanol, fully 40% of the annual corn harvest is now going for biofuels.

The water required, ranges from 7 liters of water for every 1 liter of corn-derived ethanol, up to 2,000 liters, depending on whether the corn is irrigated. Thus 90 billion liters of ethanol worldwide consumes at least 637 billion liters of water, equivalent to the annual municipal water use of a city of 4.5 million people.[7]

Backward Policies

This issue is not only that these two specific energy policies, fracking for natural gas and biofuels, use a lot of water. If they also provided an energy source that could upgrade the entire economy, then they could be part of an overall upshifting of the economic system—*but this is not the case*.

The future of mankind's energy needs lies in the domain of nuclear reactions, with fission and especially fusion power. Fracking for natural gas as an energy supply is a step backward, expressing a physical economic phenomenon known as diminishing rates of

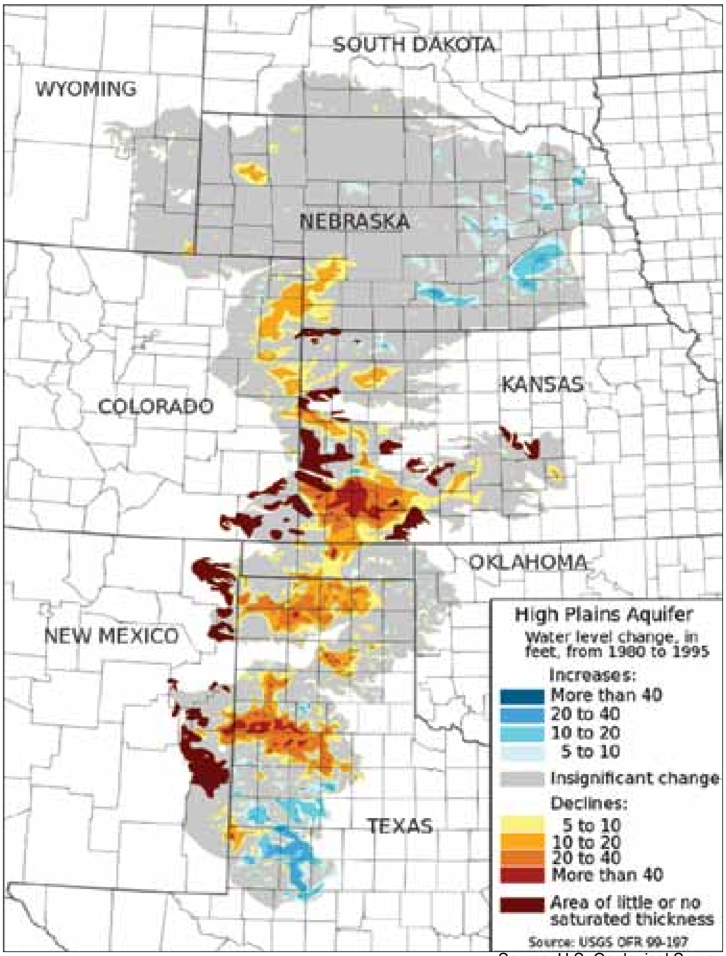
7. See "Measuring Corn Ethanol's Thirst for Water," April 14, 2009, in the *MIT Technology Review*.

return—the amount of physical effort and capital supplied is increased in order to acquire the same amount of energy, and thus the energy return per amount of physical economic input is declining. This is characteristic of a typical attrition process, when a resource base is being depleted, and the physical effort of society is increased just to maintain previous levels of production. While technological advance has certainly offset the increased physical cost by increasing the productive powers of labor, much higher order energy sources are available with nuclear reactions, rendering fracking for natural gas as a source of power, a net loss to society.

To a certain degree, the biofuels program is even more insane. In the United States, for example, the production of biofuels from corn is so energy intensive that the energy provided by the combustion of the biofuels is only 1.3 times the energy put into the production of the fuel.[8] When compared to other major energy sources in the United States, which provide 10 to 100 times more energy than the energy input required, ethanol corn is the lowest. The pitiful energy payback, combined with the water requirements and the diversion of food needed for consumption, shows support of biofuels through government subsidies to be a criminally insane policy.

Again, the future of energy and power lies in the control of atomic reactions. In addition to providing power, these higher energy flux density systems will enable mankind to solve the world water crisis. Having briefly touched on policies accelerating the water crisis, we now examine the challenges posed by groundwater depletion and surface water deficiency (and/or lack of management).

FIGURE 3
Groundwater Level Decline in High Plains Aquifer, North America, 1980-1995



Source: U.S. Geological Survey

B. Groundwater Depletion

The location and condition of major world aquifers has been mapped by many science agencies, in particular, UNESCO (U.N. Educational, Scientific, and Cultural Organization), whose International Hydrological Program in 2008 made available an extensive world database. The drawdown of groundwater resources in many places has reached the crisis stage, necessitating ever deeper pumping, while producing poor quality water. Many regions are suffering land subsidence. [9] **Figure 3** shows this for the High Plains (Ogallala)

8. United States Department of Agriculture, "The Energy Balance of Corn Ethanol: An Update," by Hosein Shapouri, et al., July 2002.

9. However, there are certain critical locations where accessible, usable groundwater has not been exploited at all, and should be developed to secure immediate water needs as a step toward the development of more advanced systems. For example, in Africa, in northwestern Sudan, where people are desperate for lack of water, there has been no infrastructure installed (pumps and storage and transmission systems) to make use of the Nubian Aquifer. A policy for peace in that region should provide plentiful water for agriculture, food processing, and domestic use for all in this region. This was called for by Dr. Farouk El Baz, space geologist and a specialist in satellite remote sensing and identification of water under the desert. See, "Farouk El-Baz, Ph.D.: Geologist Proposes 1,000 Wells for Darfur; Use Science To Serve Mankind," *EIR*, Sept. 14, 2007.

Aquifer in North America.

The general reason groundwater supplies can be problematic is that many aquifers have relatively slow recharge rates.[10] Returning to the opening concept of the terrestrial water cycle, the ultimate source for all groundwater is precipitation brought over land by the action of solar radiation. This is what built up freshwater aquifers, and is the process that maintains them. For many aquifers their cycle is so slow that it is easily outpaced by human activity. This results in a drawing-down of the cycle, and mankind must either accelerate the cycle (through the creation of new recharging systems), or create new cycles to bring in water to augment or replace groundwater use. To illustrate this, examine three examples from the United States.

The Ogallala aquifer, one of the largest in the world, supports about one-quarter of the irrigated land in the entire United States, and provides drinking water for 2 million people. According to a 2007 report by the United States Geological Survey (USGS), the water available in the entire aquifer is nearly 10% less than in 1950, and about 310 km^3 less than its "predevelopment" levels (in some regions, the water level can fall 5 feet in a year).[11] According to a 2002 USGS report to Congress, the annual depletion rate averaged over the 1987 to 1999 interval was about 5 km^3 per year[12] (about equal to California's allocation of the Colorado River), and the depletion rate since then has been increasing.

Another example is California's Central Valley. Covering 60,000 km^2, less than 1% of the United States' total farmland, the Central Valley produces 8% of the nation's agricultural output (by value), making it one of the world's most productive agricultural regions. According to a February 2014 water advisory from the University of California Center for Hydrologic Modeling, the Central Valley aquifer has lost about 75 km^3 between 1962 and 2013; that is, the groundwater is being withdrawn at rate of 1.5 km^3 per year faster than it is being recharged.[13] With the California drought intensifying, groundwater use is accelerating.

A third example from the western United States is the Colorado River basin. The basin covers well more than half a million square kilometers, and the Colorado River itself supplies water for more than 33 million people across seven states, although its flow has significantly diminished over the past decade. In July 2014 a research team led by scientists from NASA and University of California, Irvine, determined that the basin lost 65 km^3 of freshwater between December 2004 and November 2013—nearly twice the volume of Nevada's Lake Mead, the largest reservoir in the United States. This is a rate of loss of more than seven km^3 per year (nearly half the current flow of the Colorado River), and the study determined that 75% of this loss is from groundwater.[14]

Looking at the global picture, the going estimate is that worldwide aquifers have been drawn down some 20% from their former levels in recent, modern history. The annual worldwide groundwater drawdown is increasing by 1-2% each year (having tripled over the past 50 years), with a crude estimate for 2010 being about 1,000 km^3 withdrawn.[15]

Again, these aquifers are not finite stores; they are being continuously replenished, but at rates too slow to match the needs of society. As discussed below, one example of a solution for the cited three aquifers and regions of the United States had been proposed a half-century ago—moving to a higher level of control through the management of the continental water cycle that subsumes these particular aquifers—the NAWAPA proposal.

C. Surface Water Deficiency

Despite the fact that an immense amount of freshwater precipitates over land, the distribution of surface water is terribly uneven. The interactions of climate, geography, and weather ensure the "natural" availability of water differs dramatically for different regions of

10. Some aquifers do have fast recharge rates, while others no longer recharge at all, and represent finite stores of "fossil water."

11. "Changes in Water Levels and Storage in the High Plains Aquifer, Predevelopment to 2005," V.L. McGuire, http://pubs.usgs.gov/fs/2007/3029/

12. "Report to Congress—Concepts for National Assessment of Water Availability and Use U.S. Geological Survey Circular 1223," 2002.

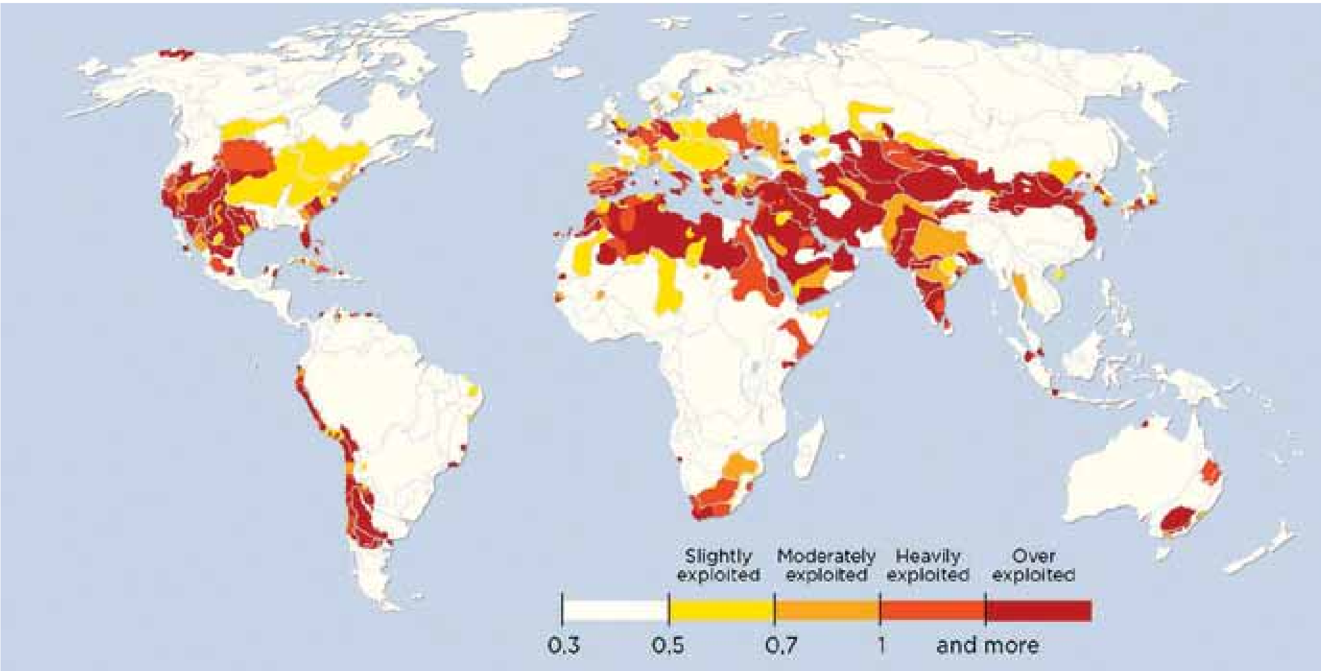
13. "Water Storage Changes in California's Sacramento and San Joaquin River Basins From GRACE: Preliminary Updated Results for 2003-2013," UC Center for Hydrologic Modeling, University of California, Irvine; UCCHM Water Advisory #1, February 3, 2014.

14. The loss isn't all from pumping, but also from the drought conditions. "AGU: Satellite study reveals parched U.S. West using up underground water," July 24, 2014. NASA, AGU joint release.

15. Of this, 67% is used for irrigation, 22% for domestic purposes, and 11% for industrial purposes. See, "United Nations World Water Development Report 2014," Chapter 2; "Water and Energy Vol. 1," UNESCO; and "Water Balance of Global Aquifers Revealed by Groundwater Footprint," Gleeson et al., *Nature* magazine, Aug. 8, 2012.

FIGURE 4

Global Water Stress Indicator (WSI) in Major Basins



World Water Assessment Programme, UNESCO, 2012.

the planet, different regions of the same continent, or even different regions of a nation, state, or province. This is reflected in **Figure 4**, which illustrates the regions of "water stress," where existing water supplies are inadequate to meet the needs of society.

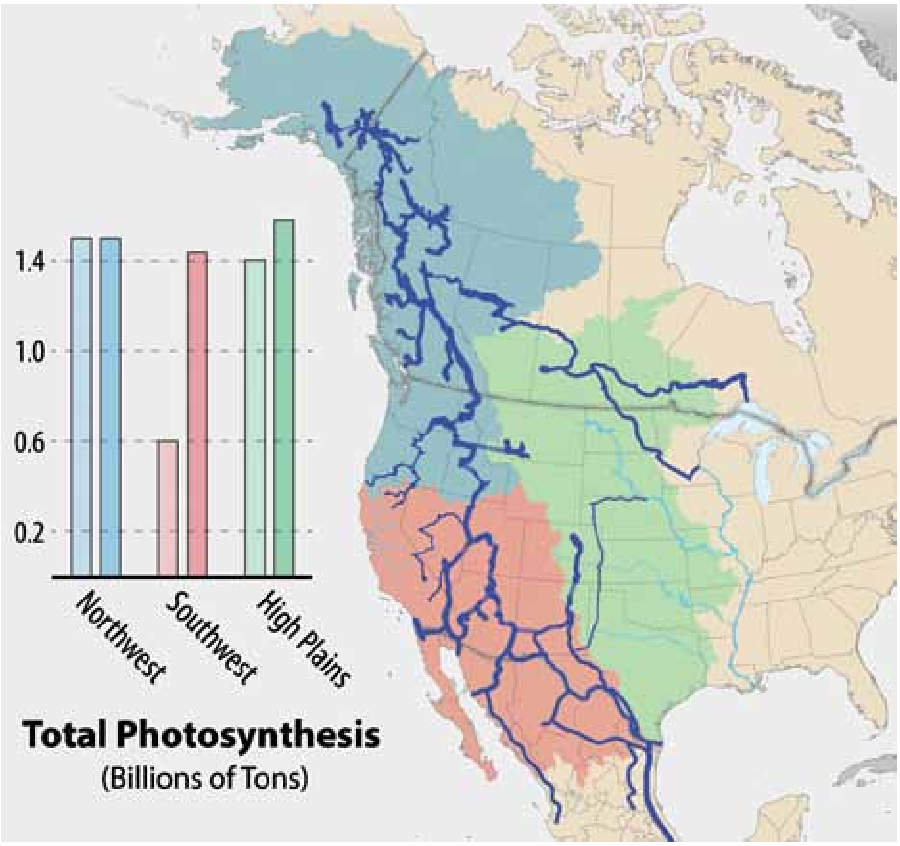
Rather than living with such disparity, mankind can manage and improve these terrestrial water cycles in two categorical ways: by ensuring the surface water is distributed in a useful manner, and by increasing the productivity of the existing cycles. This is largely accomplished through basic infrastructure systems such as dams, reservoirs, canals, pumps, irrigation, water purification, and sanitation.

In most regions this type of development has been held back, and huge potentials remain unutilized. There are two outstanding exceptions—in North America in the first half of the 20th Century, with the Tennessee and the Colorado/California River Basins; and today in China, with the great South-to-North Water Transfer System, regulating and redirecting flow from the Yangtze Basin to the Huang Ho Basin.

In the 1930s, Franklin Delano Roosevelt's Tennessee Valley Authority (TVA) tamed the wild and erratic conditions of the rivers of the Tennessee Valley. Periodic flooding and fluctuations in water availability severely limited the potential for development. The TVA constructed a series of dams and reservoirs to ensure the steady and regular flow of water, during times of excess and during times of scarcity. This greatly improved agriculture, and enabled new navigation and transportation, as well as the development of hydroelectric power. The project transformed a region that suffered from poverty and diseases such as malaria, into a cornerstone of the most advanced scientific research project ever conceived at the time, the Manhattan Project (see section on the TVA).

The dry western region of the United States faced a greater challenge. The larger territory of the Colorado River basin was brought under control through a series of major dams, reservoirs, and irrigation and related systems, led by the famous Hoover Dam and Lake Mead. Currently the agricultural, industrial, and domestic needs of up to 40 million people depend on the management of the Colorado River with dozens of major dams, hundreds of miles of canals, and irrigation water provided for 16,000 km^2. The development of the West continued with the Central Arizona Project branching off the Colorado River, and the California Water Project regulating the flow of the Sacramento and San Joaquin rivers. This is how California's Central

FIGURE 5
NAWAPA, PLHINO, PLHIGON and Photosynthesis



Source: Benjamin Deniston/EIRNS 2014

The waterways shown are the North American Water and Power Alliance system, diverting run-off from Alaska and the Yukon southward through the U.S. Southwest; and in Mexico, the diversion northward of water from the Southern and Western Sierra Madre run-off, through the systems of PLHINO (Northeast Hydraulic Plan) and PLHIGON (Northwest Hydraulic Plan). See box on photosynthesis next page.

Valley became a breadbasket for the nation, producing nearly one-tenth of the nation's crops on less than 1% of the national farmland.

However, while each of these regional developments in the American southwest have been highly successful, the total water flow of the Colorado, Sacramento, and San Joaquin rivers is relatively small for the size of the land area to be supported by them. Starting in the 1950s and 1960s, it was recognized that the larger issue that needed to be addressed is the great *continental* discrepancy between water excess in the northwest, throughout Canada and Alaska, and the water scarcity in the southwestern United States and northern Mexico. Measured by river flows, this northwestern quarter of the continent has about ten times the water availability of the southwestern quarter.

By the 1960s, designs for the grand North American Water and Power Alliance (NAWAPA) were developed to rectify this great imbalance, by proposing a continental water management system that could bring approximately 20% of the freshwater runoff from select rivers in the northwest, down throughout the southwest. From 2010 to 2014 the LaRouche PAC Basement research team re-examined NAWAPA and proposals to further augment and expand the project.[16] (See **Figure 5**) When the potentials for expansion are taken into account, NAWAPA could increase the water available for entire southwestern states by between 50% and 200%, and first order estimates indicate that it could increase the photosynthetic productivity of the water cycles of the western river basins by 30%, and the photosynthetic productivity of the entire North American continental water cycle by 10% (see box, "Increasing the Physical Productivity of the North American Water Cycle").

Because water availability in the northwest is not a limiting factor in photosynthesis, taking this relatively small fraction of water from there would have minimal effects on northwest photosynthetic productivity. Thus the total productivity of the water cycle of the western regions (northwest, southwest, and High Plains) could increase from 1.8 to 2.3 tonnes of photosynthesis per km^3—a nearly 30% increase.

The productivity of the entire continental water cycle (including regions not directly affected by NAWAPA) could be increased from 2.3 to 2.6 tonnes of photosynthesis per km^3—a 13% increase for the entire continental cycle, done without increasing the net water input, but by better management of the existing cycle.

16. See, "Nuclear NAWAPA XXI: Gateway to the Fusion Economy," *21st Century Science & Technology*, 2014.

However, despite significant support, the NAWAPA project was killed by the zero-growth movement gaining power by the late-1960s and 1970s.[17]

17. See the 2011 feature documentary, NAWAPA 1964, http://larouchepac.com/nawapa1964

The TVA was seen as a model the world over, and variations on it were proposed in many countries. In some, such as the Indus Valley in southern Asia to the North of Scotland and the Murray-Darling River basin in Australia, variations were applied. In other areas, such as Jordan, Africa, South America, and Southeast Asia, plans to apply the TVA model were developed, but blocked.

In dramatic contrast, China's grand inter-basin South-North Water Diversion (SNWD) project now stands as the near solitary, but exemplary, model of large-scale surface water organization. The three-route SNWD complex, shown in **Figure 6**, is now partially complete. The concept is to convey a portion of the abundant water supplies in the monsoonal southern Yangtze system, to the arid north. First proposed in the 1950s, designs were debated for decades; then in late 2002, construction began, and since 2009 the project has been accelerated.

The Eastern Route Project (ERP) became operational in December 2013, delivering water to the eastern provinces of Jiangsu, Anhui, and Shandong. By 2015, water in the Middle Route Project (MRP) will flow to Beijing, Tianjin, and environs. In September 2014, testing of water quality began on the MRP, preparatory to activating the full flow. The Western Route, which would capture and divert water from three tributaries of the upper Yangtze River, is still in the planning stages; it involves demanding engineering and construction work.

The SNWD dimensions are significant. The Eastern Route uses upgrades on the 1,500-year-old Grand Canal, a waterway likewise linking the south to the

Increasing the Physical Productivity Of the North American Water Cycle

The North American continental water cycle can be estimated to be about 3,150 km^3 per year (as measured by freshwater river runoff). Of that, 1,466 km^3 flows out of the northwest, and only 113 km^3 from the southwest. Using measurements and analysis from NASA earth monitoring satellites, the total amount of photosynthetic production can be estimated for these same regions. Comparing these two values allows for a simple, but insightful measure of the productivity of the continental water cycle, and of its respective basins. The figures below are measuring "billions of tonnes of photosynthesis per year" divided by "cubic kilometers of freshwater runoff per year," to measure the productivity as "tonnes of photosynthesis per cubic kilometer of freshwater flow."

North America:	7.4 billion tonnes / 3,150 km^3 = 2.3 million tonnes per km^3
Northwest:	1.5 billion tonnes / 1,466 km^3 = 1 million tonnes per km^3
Southwest:	0.6 billion tonnes / 113 km^3 = 5.5 million tonnes per km^3
High Plains:	1.2 billion tonnes / 251 km^3 = 4.8 million tonnes per km^3

These figures show, in terms of photosynthetic production, the water of the southwest is five and a half times more productive than the water of the northwest. This is a confirmation of what is intuitively clear, there is an excess of freshwater in the northwest, where the cold climate and lack of sunlight limit a more productive use of that water. By these values, a first order estimation of the effect of NAWAPA can be made, by estimating the potential increase in photosynthesis, and the increase in the productivity of the continental water cycle.

Southwest: 159 km^3 of new freshwater from NAWAPA, at a productivity of 5.5 million tonnes per km^3, could increase the annual photosynthesis of the southwest from 0.6 to 1.5 billion tonnes.
High Plains: 37 km^3 of new freshwater from NAWAPA, at a productivity of 4.8 million tonnes per km^3, could increase the annual photosynthesis of the High Plains from 1.2 to 1.4 billion tonnes.

FIGURE 6
South-North Water Diversion Project

Sources: Chinese Ministry of Water Resources; futuretimeline.net; Will Fox

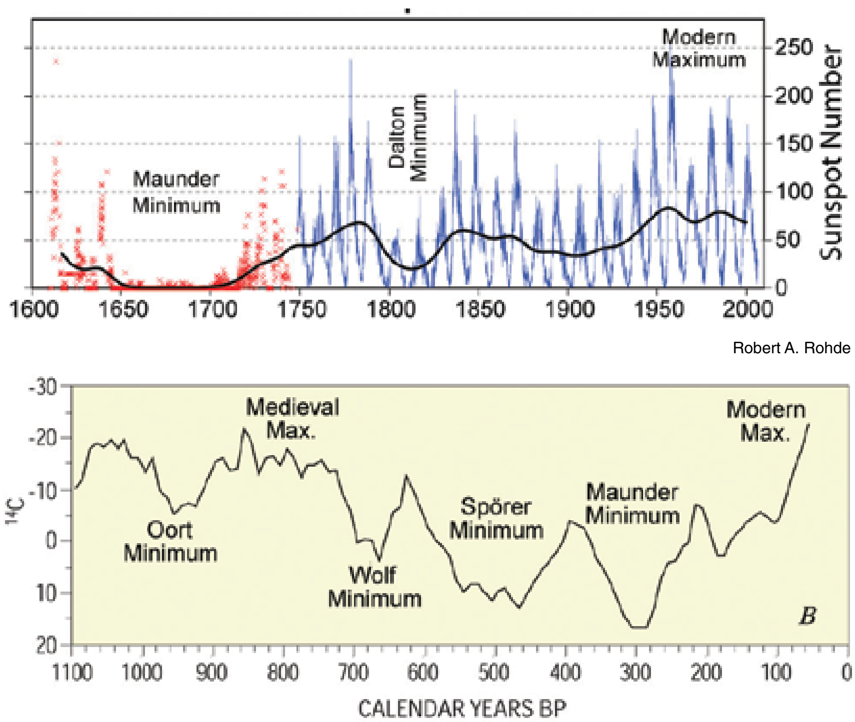
north. Today, the ERP transports some 14.8 billion m^3 of water a year. The Middle Route will carry 9-13 billion m^3. This channel required 1,400 km of new construction, with its starting point at the Danjiangkou Reservoir.

The concept of the Western Route is to transfer flows from the headwaters of the Yangtze into the headwaters of the Yellow River, to augment its flow. The hydro-engineering involves major dams and tunnels to move the water across the Qinghai-Tibetan Plateaus and Western Yunnan Plateaus, and to cross the Bayankala Mountains. These watersheds are all within China's borders; initial feasibility studies are in hand.

When complete, the three-route SNWD would transfer 20 to 40 billion m^3 from the Yangtze Basin to the dry north. In addition, there is the idea of diverting northward, some of the flow of the trans-boundary rivers—the Brahmaputra, Salween, and Mekong, which would vastly increase overall SNWD volume.

Against this background sketch of what has been done, what could be done, and what must be done with respect to surface water management, recent evidence indicates the need to re-examine all aspects of the global water crisis from a higher perspective, starting from the Sun.

FIGURE 7
400 Years of Sunspot Observation



Solar activity over 1,100 years, measured by changes in production of carbon-14 in the atmosphere. More carbon-14 is produced by the increased galactic cosmic radiation the Earth experiences when the solar activity is low.

D. Solar-Driven Climate Changes

Return again to the basic concept of the terrestrial water cycle. Ultimately all surface and groundwater stores and flows depend on the precipitation of evaporated ocean water, and, as is now being learned in the western regions of the United States, there is no basis to assume that these precipitation patterns are static, unchanging systems. Recent studies of the climate history of this western region indicate that the past thousands of years have seen extreme variations, ranging between so-called mega-droughts to mega-floods, and, against this longer background, the 20th Century had been one of the most stable and wet centuries on record.[18]

It appears the western United States could now be departing from this lucky period of climate stability and relative moisture availability. One example could be the above-cited Colorado River, which averaged a flow of 20 km^3 per year from 1900 to 2000, but a flow of only 15 km^3 per year from 2001 to 2011, and with the accelerating groundwater loss, the river's flow is expected to fall further.

This is just one example of the types of changes in climate and precipitation patterns that regularly occur, challenging existing water management systems. Many factors can be involved in such changes, including cyclical and other changes in the ocean systems and changes in the biosphere, but here we focus on the activity of the Sun. While it is not the only factor involved, changes in solar activity is one of the most ignored and important factors.

Solar Cycles, Grand Minima, and Regional Climates

The Sun goes through a roughly 11-year cycle, as measured by the increasing and decreasing number of sunspots visible on its surface. While sunspot counts are the most long-standing observational measure of solar cycles (with regular records going back to the 17th Century), we now know these are just one expression of much more dynamic, and little understood, periodic changes of the Sun's activity, changes which extend far beyond the Sun's surface, permeating the solar atmosphere which envelops all the planets, including Earth.

While the average length of a solar cycle is 11 years, the actual length of a given cycle can vary, as can its strength. There can be longer periods of a series of strong solar cycles (measured by large numbers of sunspots), periods of a series of weaker solar cycles, or even periods where the sunspots seem to disappear for decades (see **Figure 7**). For example, the first few cycles of the 19th Century were very weak, defining a period known as the Dalton Minimum. Earlier, between 1650 and 1700, there were few or no sunspots at all, as if the solar cycle simply disappeared for more than half a century, a period now known as the Maunder Mini-

18. "The West Without Water: What Past Floods, Droughts, and Other Climatic Clues Tell Us About Tomorrow," by B. Lynn Ingram and Frances Malamud-Roam, Berkeley; University of California Press, 2013.

mum. This has been called a solar "grand minimum," and was just the most recent of several grand minima over the past 1,000 years.

The period of the Maunder Minimum is famous for another reason; it corresponds to the time of the little ice age throughout Europe. The prospect has been raised, that perhaps these periods of solar grand minima can have significant influences on the Earth's climate systems.

There are now many studies that point in this direction. From a survey of various investigations of past climate and hydrological variations in locations all around the globe, an interesting pattern emerges. During periods of solar grand minima, multiple records from the northern regions show evidence for significant cooling (at least four different sites across Eurasia); records from the tropics show an increase in average precipitation (at least three different sites across Africa and South America); and records from the subtropics show less precipitation and increased drought (at least ten different sites across Asia and the Americas).

Typical of these studies is a 2012 paper by members of the Chinese Academy of Sciences, which used tree ring measurements from the Tibetan plateau (where trees are very sensitive to water availability) to show that periods of low solar activity and solar grand minima correspond to periods of drought.[19] Different studies have been done for the South China Sea, Pakistan, Southwest Asia, eastern India, and several sites in the region of the Caribbean, Central America, Florida, and Mexico—all indicating less precipitation during periods of solar grand minima.

While there is still much to understand about the effects of changing solar activity on the Earth's weather, climate, and hydrological systems, there is increasing evidence that the Sun is currently weakening, and could be going into a new period of prolonged lull, perhaps a new grand minimum.

No one knows for certain what the Sun will do, and no one knows for certain what the exact effects of a new solar grand minimum would be. But we do know that dramatic shifts in climate and hydrological patters do occur, and they have been associated with solar variations in the past. However and whenever such shifts occur, mankind must be prepared to handle such changes.

This means that solely relying on existing patterns of precipitation, and the existing levels of surface and ground water flows created by those precipitation patterns, may not be enough. Even large-scale river diversion systems could be vulnerable to such shifts. Ultimately the future of water on this planet requires not only managing historical surface and groundwater flows, but investigations into managing the subsuming atmospheric moisture flows, and large-scale desalination for the creation of completely new, man-made terrestrial water cycles.

This completes the review of the qualitative characteristics of the water challenges facing mankind, laying the basis to examine to concepts needed to solve these issues.

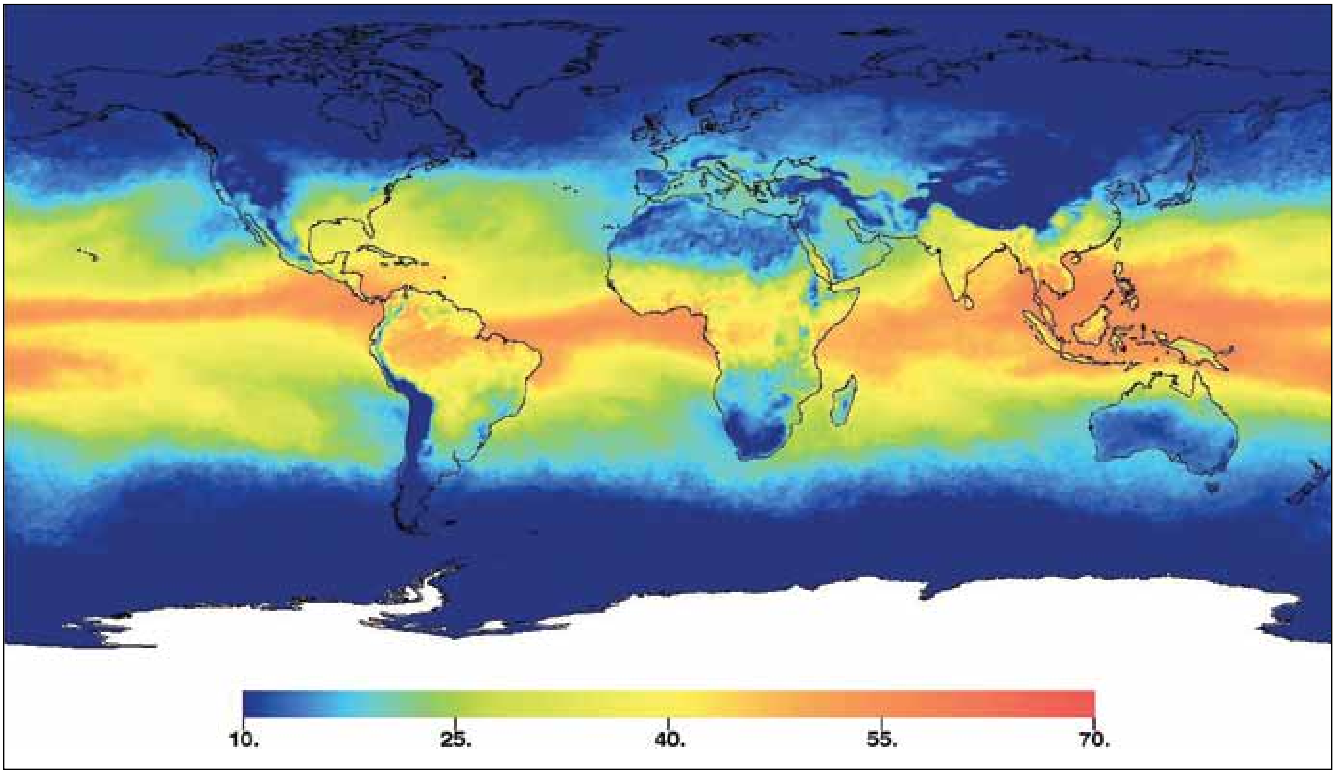
II. The Future of Water: A Global Perspective

The technology exists to develop new water resources. Working from the standpoint of the terrestrial water cycle, we can define two broad categories of action. First, managing and improving use, efficiency, and productivity of existing terrestrial water cycles. Second, recognizing the expected fluctuations in these natural cycles, mankind must be prepared to go to a higher level of control over existing water cycles, and even creating new ones.

In the first category, managing existing cycles, there are two subcategories of action that can be taken. First, improved water management systems can increase the efficiency and reuse of existing water supplies, increasing the productivity of existing cycles. Second, river basins and continental river systems can be developed and improved with large-scale river diversions, dams, and irrigation systems. Examples of existing and proposed regional and continental river diversion and management systems were discussed above. These are crucial and must be developed, but, as California and nearby states are now experiencing, they may not always be enough.

This takes us to the need to focus attention on the second category—controlling existing water cycles and even creating new ones, and two distinct subcategories

19. "Tree Ring Based Precipitation Reconstruction in the South Slope of the Middle Qilian Mountains, Northeastern Tibetan Plateau, over the Last Millennium," by Sun and Liu, 2012. *Journal of Geophysical Research: Atmospheres*.



NASA/JPL

Aqua/Atmospheric Intrared Sounder (AIRS) Total Precipitable Water Vapor (mm) May 2009

that can be defined therein. First, atmospheric moisture flows and rainfall can be influenced, and potentially controlled, with weather modification technologies. Second, with the development of abundant power from nuclear fission and thermonuclear fusion level economies, new freshwater resources can be produced with ocean desalination systems on a large scale. First, on weather modification.

A. Resources 'In the Sky'

Referring back to the global water cycle estimates, less than 10% of ocean evaporation precipitates over land, meaning there is an immense store of untapped freshwater in the atmosphere. The flux of moisture from the oceans into the atmosphere is incredible, equivalent to about 1,000 Mississippi Rivers, flowing up, from the oceans into the sky at all times.

Can this atmospheric water be induced to fall where it is most needed, or kept from falling where it causes harm? Cloud seeding has shown limited success under certain conditions, and various other schemes have been proposed to induce atmospheric moisture to come down to land. However, here we highlight the potential of a lesser-known approach, based on the electrical properties of the atmosphere and of weather systems—that of atmospheric ionization systems.

This technique uses towers and arrays of wires, through which a precisely tuned current is run, ionizing the surrounding atmosphere. Increasing the ionization of the atmosphere can help to facilitate the formation of clouds and rainfall. Operating on the right scale, these systems could be able to draw more ocean moisture over land, increasing the overall terrestrial water cycle. These techniques have been used in Russia, the United Arab Emirates, Mexico, Israel, and Australia. We examine a few case studies.

Case Study: Mexico

In the 1990s, the then-director of the National University of Mexico's Space Research and Development Program, Dr. Gianfranco Bissiachi, began collaboration with a Russian scientist, Dr. Lev Pokhmelnykh, who had worked on weather modification in Russia since the 1980s. Supported by Heberto Castillo, then-president of Mexico's Senate Committee on Science and Technology, in 1996, Pokhmelnykh and Bissiachi oversaw the development of an initial network of three ionization stations based on Pokhmelnykh's designs. The initial results generated enough interest and support that the system was expanded from three stations in 1999, to 21 by 2004, and further success led to the expansion to 36 stations by 2006.

In 2003, the Massachusetts science publication *Mass High Tech* ran an article discussing the potential use of ionization systems in the United States, based on the precedent set in Mexico. It describes the success of the first Mexican ionization station as follows:

"That country's first [ionization] station, in the drought-stricken state of Sonora, increased average rainfall from 10.6 inches to 51 inches in the first year, according to Mexican department of agriculture statistics. When a lack of state funds shut down the station the following year, area rainfall measured 11 inches. In the third year, with the station operational again, the area recorded 47 inches of rainfall. [In 2003 the technology was operational] in eight states in the driest regions of Mexico, and some areas [reported] a doubling or tripling of annual rainfall."

In 2004, *IEEE Spectrum* also covered these Mexico operations, citing a doubling of the average historical precipitation in Mexico's central basin, resulting in a 61% increase in bean production in the affected areas. A 2008 paper on the potential use of these ionization systems in Texas analyzed the rainfall levels in the central and southern regions of the Mexican state of Durango. Each year from 1999 to 2003 showed a significant increase in rainfall over the expected levels. The authors of the paper calculated that there was less than a 1 in 400 billion chance that this could have happened by happenstance.[20] Despite these indications of successful results, the Mexico operations have lost the needed financial support.

Case Study: Israel

Lev Pokhmelnykh began developing ionization-based weather modification systems in Israel, using an installation of three stations. Starting in late 2011 they induced increased rainfall in the Golan Heights area, filling seven reservoirs to full capacity, something which has not occurred in the 40 years since the construction of these reservoirs.[21]

Case Study: Australia

In 2007, the weather modification company Australian Rain Corporation was formed, with the intention to develop ionization systems to stimulate rainfall. In 2007 to 2008 the Australian Government's National Water Commission funded some initial trials. From 2008 to 2010, Australian Rain Technologies ran three trial programs:

Paradise Dam, Bundaberg (January-May 2008): Resulted in a 17.6% increase above anticipated rainfall in a 30° downwind arc from the system.

Mt. Lofty Ranges, Adelaide (August-November 2008): Produced an increased rainfall of 15.8% above the anticipated levels over a 120° arc downwind from the system.

Mt. Lofty Ranges, Adelaide (August-December 2009): Generated an increase of 9.4% over an area roughly twice the size of the previous trials.

In 2011, the company submitted a proposal to the Parliament's Standing Committee on Regional Australia, requesting $11 million to construct 14 ionization stations distributed around two catchment areas in southeastern Australia (Gwydir River and Hume-Dartmouth catchment) to increase the rainfall going into the irrigation systems of the Murray-Darling Basin (one of the most significant agricultural areas in Australia, which is facing a major water shortage, largely because of environmentalist-imperial policies).[22]

Case Study: United Arab Emirates

In early 2011, a barrage of media reports covered a leaked report of a weather modification program in the United Arab Emirates. The story broke when the London *Sunday Times* detailed a contract with a Swiss company, Meteo Systems International, to build a series of ionization stations to bring rain to regions of the UAE, including the capital, Abu Dhabi.

The initial coverage claimed evidence for success-

20. See, "Expanding NAWAPA XXI: Weather Modification To Stop Starvation," *EIR*, August 9, 2013.

21. "Inducción Experimental De Lluvias Por Ionización Atmosférica En Las Alturas Del Golán, Israel, En El Período Invernal 2012-2013," by Mario Domínguez and Lev Pokhmelnykh, May 2013.

22. See, "Expanding NAWAPA XXI: Weather Modification To Stop Starvation," *EIR*, August 9, 2013.

ful operations in 2011, pointing to 52 unanticipated rain showers, and citing interest from numerous scientists involved.

According to the website, the company was started in 2004, ran trials in Switzerland in 2005, and then started trials in the UAE in 2006 and Australia in 2007 before getting funding for an additional trial in Al-Ain, UAE. The website proclaims, "Meteo Systems' WeatherTec™ is an old idea that has been developed and enhanced over years of scientific research and trials."[23]

These four case studies have indicated the potential of these ionization-based weather modification systems. More work needs to be done, and perhaps other methods will be developed, but this opens a critical window into an entire category of action for mankind. Instead of relying on existing precipitation patterns and surface water availability, mankind could potentially take a higher level of control, by affecting atmospheric moisture flows, gaining a greater degree of control over the terrestrial water cycle, and even increasing the rate of the cycle by drawing more ocean moisture over land.

This takes us to the second subcategory of the second general category of action, using higher levels of energy flux density to create completely new terrestrial water cycles through desalination.

B. EFD and Desalination

Everything up to this point has depended on solar evaporation for desalination and transportation of freshwater. But now, for the first time in the entire history of the planet, a new force has emerged.

Mankind can produce freshwater directly from the oceans with desalination systems, opening up the first freshwater production in the biosphere that is not controlled by solar activity. The technology and methods exist, and are improving in their efficiency. What is needed is the mass development of fission and fusion power, in order to be able to expand desalination to the scale needed by mankind. This is a clear expression of the role of higher energy flux density in changing the resources available in an economy.

With the higher quality power sources of fission and fusion, the power available per person in an economy can be greatly increased (the national economic energy flux density), enabling more power to be applied to the development of resources that could not be developed for large-scale use at lower levels of national economic energy flux density. This is the case with the production of water via desalination.

There are already several well-developed industrial methods for the desalination of salt water, processes that have been continually improved over decades, and their merits demonstrated in years of use in large-scale non-nuclear installations and a few small scale nuclear-powered facilities.[24] At present, non-nuclear desalination is providing some freshwater for about 300 million people worldwide, when many millions more are in need, located where no adequate freshwater sources exist.

The total number of desalination facilities globally, is more than 15,000, almost all of them fossil fuel-powered. The top echelon of large plants in this inventory are concentrated in Southwest Asia—in the Persian Gulf, and recently, in the transJordan in Israel. These big plants account for most of the world's annual capacity of nearly 30 km^3 of freshwater produced by desalination. The thousands of other, smaller, low-volume desalting plants, are mostly located in remote communities, in such places as hotels on resort islands in the Caribbean and Mediterranean and for high-value food processing. While the current world capacity of 30 km^3 per year is impressive—equivalent to twice the Colorado River, or one-fifth the discharge of the Nile River (a sizable increase from the desalination capability of 20 years ago of 5.5 km^3)—today's output is nevertheless far short of what is required to meet the needs of those in the many water-short dry-land areas internationally.[25] Recall that in 2011 about 1,000 km^3 of groundwater were depleted, 33 times more than the current global desalination rate.

23. Ibid

24. Two main methods involve the use of heat to evaporate water and the use of membranes to filter water. These desalting methods are described in the "Expand Nuclear Power for the World's Survival" section of this report.

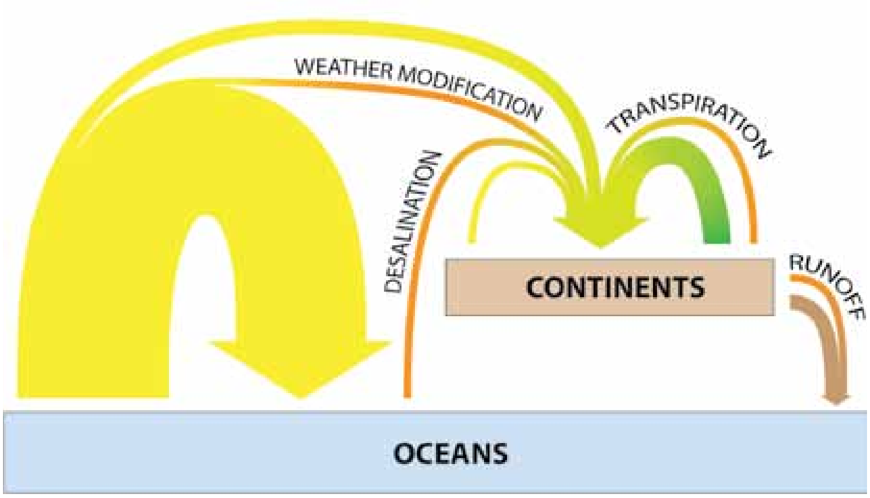
25. The geography of priority locations for nuclear mass-output of desalinated water is obvious. It includes the entire Middle East–North Africa region; the southern Indian Subcontinent; Southwest Asia from the Mediterranean through to Pakistan; the water-short areas of the Pacific Rim in northern China, southwestern North America, and along the west coast of South America; parts of the South Atlantic, including northeastern Brazil and Southwestern Africa; and parts of Australia. In addition, there are priority inland regions of Eurasia, including the Aral Sea Basin, dry-lands of Mongolia, and elsewhere.

While the oil- and gas-rich nations of the deserts of southwest Asia (led by Saudi Arabia) have pioneered the development of hydrocarbon-powered desalination, it will be the energy flux density of the nuclear era that will enable the true breakout of desalination on the global scale needed, matching and outpacing the depletion rates of regional water cycles. This can be illustrated with a pedagogical example. As cited above, the Colorado River basin is losing water at a rate of 7 km^3 per year. To provide this much water with the most efficient desalination systems currently available[26] would require a very large amount of power, and an incredible supply of fuel, when using anything but the power of the atom. If coal were used to desalinate as much water as is being lost from the Colorado basin, it would require 6.7 million tonnes of coal per year—enough to fill 67,000 rail cars, equivalent to a train that would stretch the entire length of California, from Mexico to Oregon.

But if the desalination system were powered by a typical uranium fuel cycle for nuclear fission, it would require 100,000 times less fuel by weight, or roughly 50 tonnes per year, which could be transported by a single semi-trailer truck. If the advanced fusion fuel of helium-3 could be developed and used, then only one-third of one tonne of helium-3 would need to be delivered from the Moon to provide the power needed to match the water deficit of an entire river basin (20 million times less fuel than coal). This one-third of one tonne could fit in the back of a regular pickup truck.

This is just one illustration of the five to seven orders of magnitude difference in the energy density of nuclear reactions over any form of chemical reaction. While fusion power is being developed, the most immediate concern will be the development of the nuclear fission systems that can open up this entire new era of water resources for mankind—effectively creating rivers, flowing from the ocean inland. This is beyond water cycle management, and in the domain of water cycle creation, demonstrating the truly unique power of mankind as a creative force on this plant.

FIGURE 8
Global Terrestrial Water Cycle Under Mankind's Control



Benjamin Deniston/EIRNS 2014

C. A Conceptual Synthesis

The current global water crisis is less about where water is and is not, and more about what mankind is, as a uniquely creative force on the planet. Mankind has before him, either the existing capabilities, or the potential to develop the needed capabilities to handle global water systems as a whole (see **Figure 8**).

As discussed above, the hydrological actions available to mankind fall into distinct principled categories.

Category 1 – Managing and improving the productivity and distribution of existing terrestrial water cycles:

Subcategory A – Improved water management systems can increase the efficiency and reuse of existing water supplies, increasing the productivity of an existing water cycle by ensuring there is a higher amount of productive use per cycle.

Subcategory B – River basins and continental river systems can be developed and improved with

26. Using reverse osmosis, operating at the expected efficiency of the new desalination plant being developed in Carlsbad, California (10.8 megajoules per m^3 of desalinated water).

large-scale river diversions, dams, and irrigation systems, to ensure the equitable distribution of water across a given land area.

Category 2 – Modulating, increasing, and creating terrestrial water cycles:

Subcategory C – Atmospheric ionization technologies are perhaps the beginning phase of a new focus on influencing and controlling atmospheric moisture flows and rainfall, opening the potential to begin to control terrestrial water cycles on a higher level—moving beyond simply dealing with the water that has fallen on land, and into influencing the atmospheric moisture flows that determine the water distribution on land.

Subcategory D – With the development of nuclear fission and thermonuclear fusion energy flux densities new freshwater resources can be produced with ocean desalination systems on a large scale.

There is no single technology that will solve the global water crisis. All these categories of action must be developed and employed in the varying degrees required for a particular region. The solution to the global water crisis is for mankind to realize his obligation to develop, scientifically and technologically, as a creative force on this planet.

The great Ukrainian-Russian scientist Vladimir Vernadsky scientifically defined the absolute distinction of the human species from forms of simply animal life. This was expressed, for Vernadsky, by the emergence of the domain of mankind's action, the noösphere, which came to dominate and overpower the biosphere. Today, a new stage of the noösphere is within reach, the expansion of mankind's creative influence throughout the Solar System. Perhaps it is only a small beginning, but the prospect for mankind beginning to control and create our own terrestrial water cycles signifies the emergence of this process.

This is mankind beginning to play a role on planet Earth that was otherwise fully reserved only to the action of the Sun itself. Only in that scientific understanding of the significance of mankind's role on Earth, and beyond, will the global water needs of the human species be addressed far into the future.

Research contributed by Mary Burdman and Marcia Merry Baker