New Manhattan Project Proposal
World Water Crisis Centre
Erice, Sicily

Submitted to:

Professor Antonino Zichichi
World Federation of Scientists
Lausanne, Switzerland

Prepared by:
Pollution Monitoring Panel

Chairman, Chancellor Em. Lorne G. Everett

World Federation of Scientists in collaboration with the United Nations Education, Scientific and Cultural Organization (UNESCO), NASA Jet Propulsion Laboratory and the Russian Academy of Sciences

September 2016

TABLE OF CONTENTS

WORLD FEDERATION OF SCIENTISTS
New Manhattan Project Proposal
Pollution Panel Task Force
Establishment of World Water Crisis Centre, Erice Sicily

1.0 INTRODUCTION

The World Economic Forum, whose membership includes heads of state, CEOs, and civic leaders, ranked water crises as the top global risk to industry and society over the next decade. They stated that, "Global water crises – from drought in the world's most productive farmlands to the hundreds of millions of people without access to safe drinking water – are the biggest threat facing the planet over the next decade". *http://www.circleofblue.org/waternews/2016/world/global-risk-report-2016*

The Permanent Monitoring Panel on Pollution has routinely addressed water issues through its annual sessions at the Planetary Emergencies Conference in Erice. This document serves as a proposal for the establishment of a World Water Crisis Centre to address key water issues on an ongoing basis under the "New Manhattan Project" initiative of the World Federation of Scientists. The purpose of the Centre is to move the PMP from just identifying and reporting on water issues to a proactive position to influence and reduce water crises around the world.

2.0 BACKGROUND

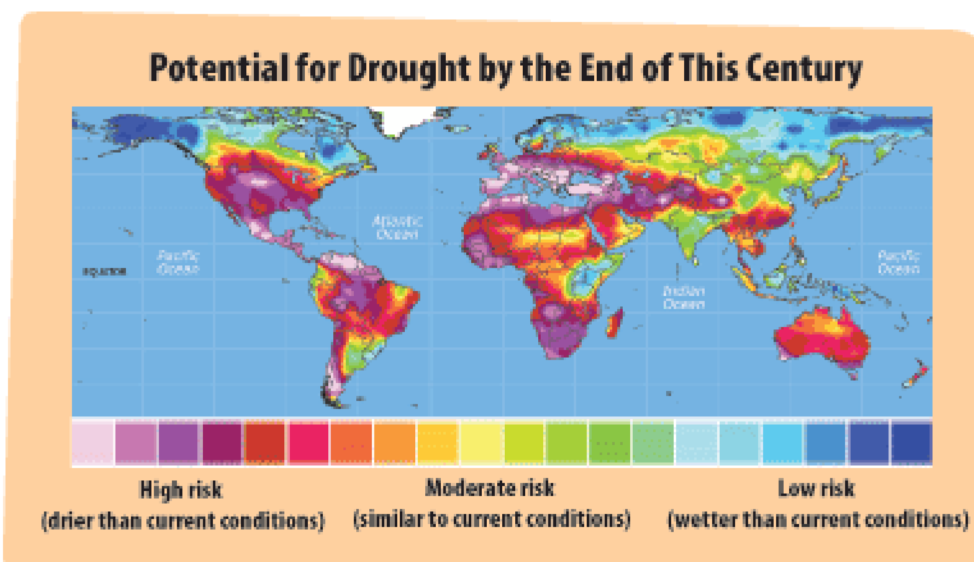
Water is crucial to life, and a readily available supply of water is required for civil society to develop, progress, and prosper. Water supplies are critical for drinking, sanitation, energy, and food production. These uses of water are central to basic survival and no societal advancement can be made until these baseline functions are fulfilled. Throughout history, the development of civilization has been closely linked to water. The cradles of civilization throughout the word have a close nexus to water supplies. Areas such as Mesopotamia (land between rivers) in the Middle East, the Nile Valley in Egypt, The Indus River in India, the Mekong and Yellow Rivers in Asia, the Mississippi River's Cahokia Civilization in North America and the settlement of Chico Norte in Supe Valley of Peru are examples of how our ancestors relied upon water as the backbone that supported their cultures and allowed them to thrive. Drought and lack of water has also led to the cultural collapse of civilizations such as the Old Kingdom in Egypt and the Anastasi in the American South West among others.

Modern civilizations are no different than that of our predecessors when it comes to reliance upon water. In 2012, Major General Richard Engel the Director of Environment and Natural Resources for the US National Intelligence Council gave a briefing on water. The first key Judgement in the briefing was, "During the next 10 years, water problems will contribute to instability in states important to US national security interests. Water issues by themselves are unlikely to result in state failure; however, water problems-when combined with poverty, social tensions, environmental degradation, ineffectual leadership, and weak political institutions-contribute to social disruptions that can result in state failure." Many people hypothesize that much of the current unrest in Syria started with a drought and the resulting rise in food prices. Around the world, water supplies are not keeping up with the growing demands of an increasing population for a variety of reasons including: (See appendix A2)

Periodic and long term droughts: Extreme drought conditions have plagued a variety of spots around the world in recent years including California, Texas, Australia, The Amazon Basin as well areas more used to seeing such conditions such as North Africa and the Mideast.

Well-known historical droughts include:

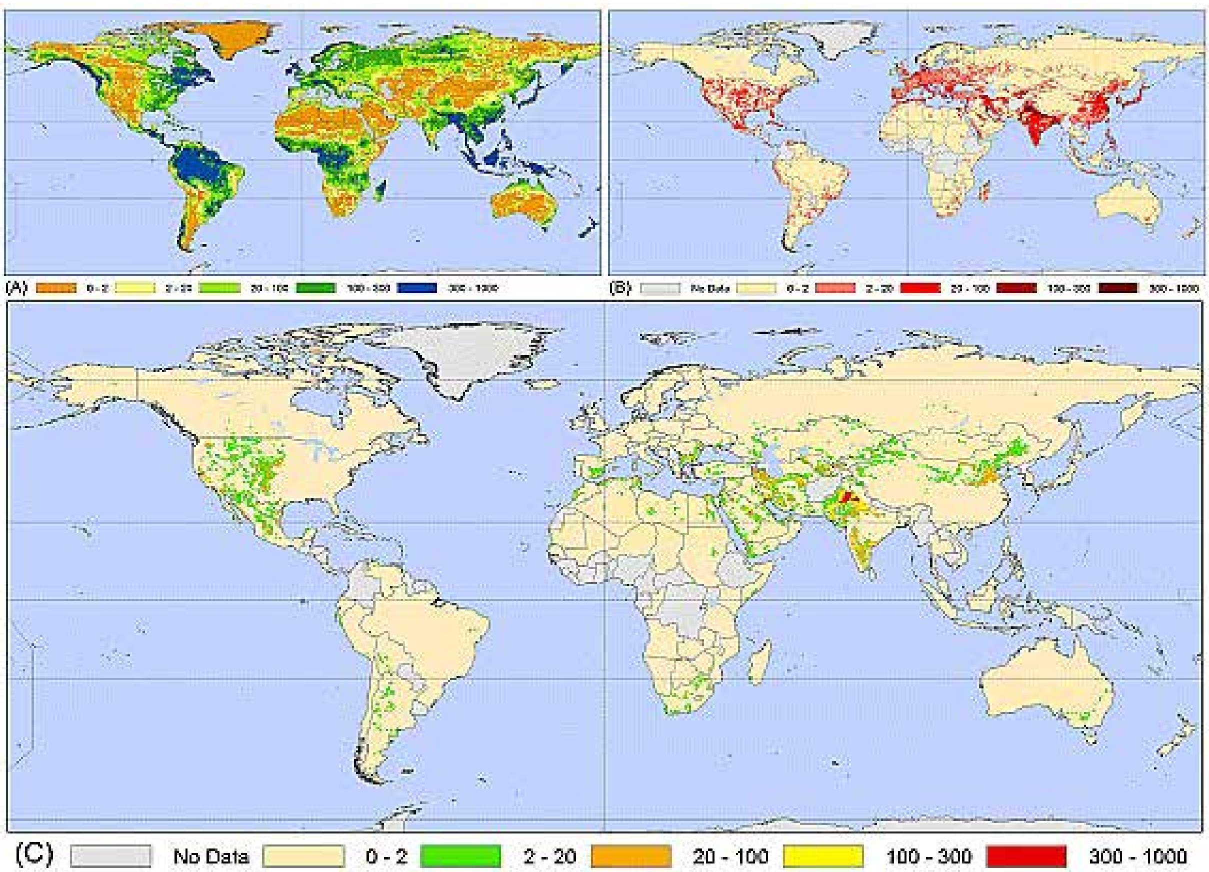
- 1900 India killing between 250,000 to 3.25 million.
- 1921–22 Soviet Union in which over 5 million perished from starvation due to drought
- 1928–30 Northwest China resulting in over 3 million deaths by famine.
- 1936 and 1941 Sichuan Province China resulting in 5 million and 2.5 million deaths respectively.
- The 1997–2009 Millennium Drought in Australia led to a water supply crisis across much of the country. As a result, many desalination plants were built for the first time.
- In 2006, Sichuan Province China experienced its worst drought in modern times with nearly 8 million people and over 7 million cattle facing water shortages.
- 12-year drought that was devastating southwest Western Australia, southeast South Australia, Victoria and northern Tasmania was "very severe and without historical precedent".



This map shows the results of computer models that have projected the risk of drought for the years 2090 to 2099. *Source: Adapted from Dai (2011).*

Depletion of ground water resources: Severe depletion of ground water resources around the world is occurring at an alarming rate. This rapid and unsustainable mining of a slowly replenishable resource is an impending crisis. A World Bank study indicates that China is over pumping three river basins in the north—-the Hai, which flows through Beijing and Tianjin; the Yellow; and the Huai, the next river south of the Yellow. Since it takes 1,000 tons of water to produce one ton of grain, the shortfall in the Hai basin of nearly 40 billion tons of water per year (1 ton equals 1 cubic meter) means that when the aquifer is depleted, the grain harvest will drop by 40 million tons—enough to feed 120 million Chinese.

In Tamil Nadu, a state with more than 62 million people in southern India, wells are going dry almost everywhere. According to Kuppannan Palanisami of Tamil Nadu Agricultural University, falling water tables have dried up 95 percent of the wells owned by small farmers, reducing the irrigated area in the state by half over the last decade.



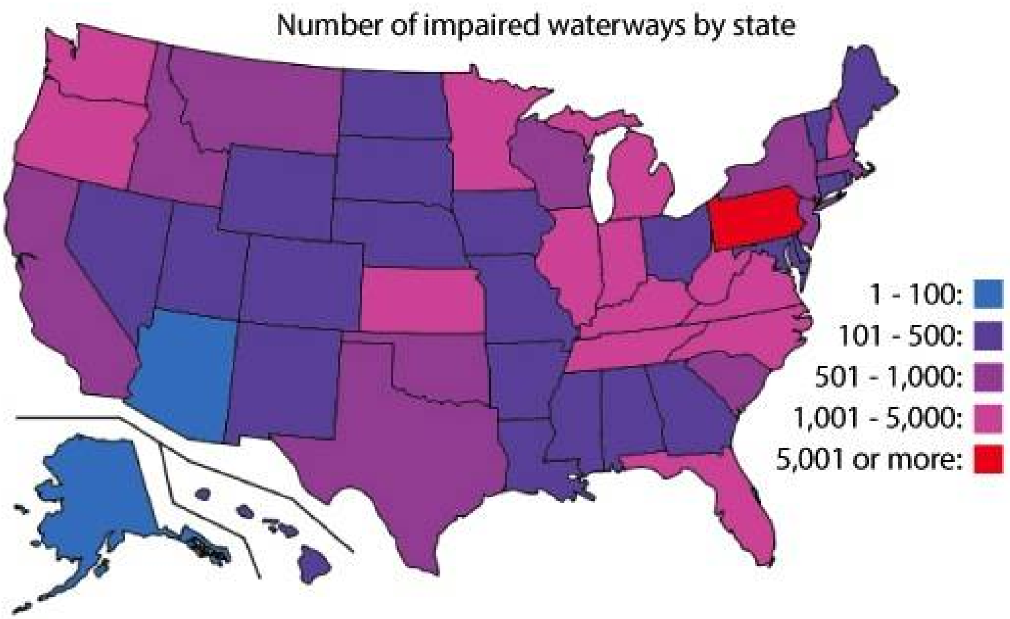
(2017) Simulated average groundwater recharge by PCR-GLOBWB, (b) total groundwater abstraction for the year 2000 and (c) groundwater depletion for the year 2000 (all in mm a−1).

Mexico City may be one of the worst examples of groundwater depletion. Mexico City was built on an old lakebed that is surrounded by mountains. It does not have access to a nearby surface water source, so the city must rely heavily on the underground aquifer for the people's water needs. The Mexico City Aquifer has been depleted since the early 1900s. One study showed that from 1986 to 1992 the aquifer lowered anywhere from 6 to 10 meters in heavily pumped areas. This massive depletion of the aquifer has caused multiple problems for Mexico City. One major problem is that severe land subsidence has occurred. Land subsidence occurs when porous formations that once held water collapse, which results in the surface layer settling. Some areas of Mexico City are rapidly sinking. These areas, such as the central section of the metropolitan area, have fallen as much as 8.5 meters. This has caused damage to many of the buildings as well as ancient monuments that are located in those sections. The monuments as well as buildings are sinking at angles, causing damage to their infrastructures. The subsidence is also damaging the sewer system. This could potentially cause the untreated sewage to mix with the fresh water in the aquifer. More than 95% of the hazardous waste generated by companies is dumped directly into the municipal sewage system. If the waste mixes with the fresh water in the aquifer it could render the only water supply to the city unusable.

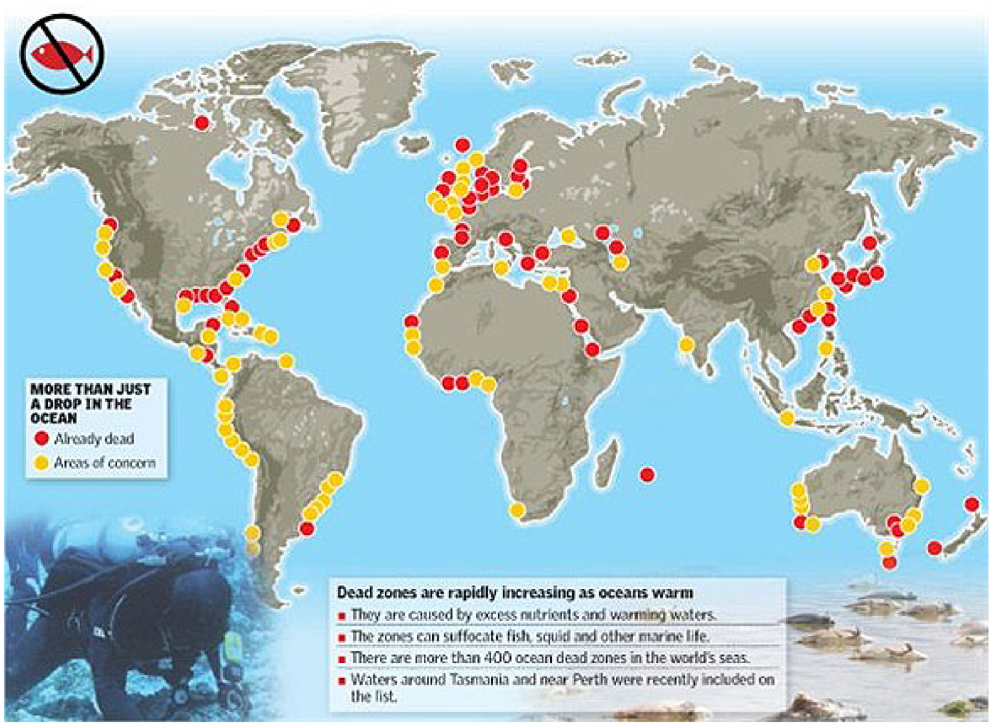
Industrial pollution of source waters: Industrial pollution of both surface and ground waters is a growing concern around the world. China is a prime example. About one third of the industrial waste water and more than 90 percent of household sewage in China is released into rivers and lakes without being treated. Nearly 80 percent of China's cities (278 of them) have no sewage treatment facilities and few have plans to build any and underground water supplies in 90 percent of the cities are contaminated. Water shortages and water pollution in China are such a problem that the World Bank warns of "catastrophic consequences for future generations." Half of China's population lacks safe drinking water. Nearly two thirds of China's rural population---more than 500 million people---use water contaminated by human and industrial waste.

In Yale University's 2012 Environmental Performance Index, China is one of the worst performers (ranked 116 out of 132 countries) with respect to its performance on changes in water quantity due to consumption, including industrial, agricultural, and household uses. In summer of 2011, the Chinese government reported 43 percent of state-monitored rivers are so polluted, they're unsuitable for human contact. By one estimate one sixth of China's population is threatened by seriously polluted water. One study found that eight of 10 Chinese coastal cities discharge excessive amounts of sewage and pollutants into the sea, often near coastal resorts and sea farming areas. Water pollution is especially bad along the coastal manufacturing belt. Despite the closure of thousands of paper mills, breweries, chemical factories and other potential sources of contamination, the water quality along a third of the waterway falls far below even the modest standards that the government requires. Most of China's rural areas have no system in place to treat waste water and the situation is not much better in western countries with a strong environmental ethic. In the US, the USEPA estimates that 55 percent of monitored waterways in the United States are impaired by pollution — meaning they are not clean enough for healthy recreation, public drinking water and subsistence fishing. Increasing industrialization worldwide as well as the recognition of new pollutant classes such as endocrine disruptors and personal care products is likely to result in an increase in pollution levels found in water.

Industrial pollution entering a waterway.



Agricultural and municipal sewage pollution of source water with nutrients leading to eutrophication: A major pollution problem being experienced worldwide is the eutrification of our lakes, rivers, streams and oceans caused by excess nutrients (most specifically Phosphate and Nitrate) being introduced into receiving bodies of water. These excess nutrients cause rapid growth of algae and cyanobacteria. When these organisms die and begin to decompose, they consume all of the available dissolved oxygen in the water column resulting in anoxic conditions and the die off of aquatic species. Areas where this



commonly occurs are found around the world. Dead zones can dramatically affect the ability of the oceans to provide sustainable fisheries hence diminishing overall world food supplies.

The nutrients finding their way into the environment are form 2 major sources. Agricultural practices and point sources. One of the major point sources is municipal wastewater disposal. Many cities worldwide are finding themselves under consent decrees and new regulations requiring the refurbishment of their wastewater facilities to cut down on sewerage overflows and nutrient deposition in water ways. Many of these refurbishments will cost 10's and even 100's of millions of dollars. The provision of water and wastewater services is also an energy intensive proposition.

Besides eutrophication, algal blooms can also release harmful toxins. In 2104, the Lake Erie derived water supply of Toledo, Ohio was shut down due to such a bloom. As Eutrophication problem continue to rise around the world such incidents of water supplies being compromised by algae related toxins will continue to increase.

Satellite photo of Lake Erie Algae Bloom

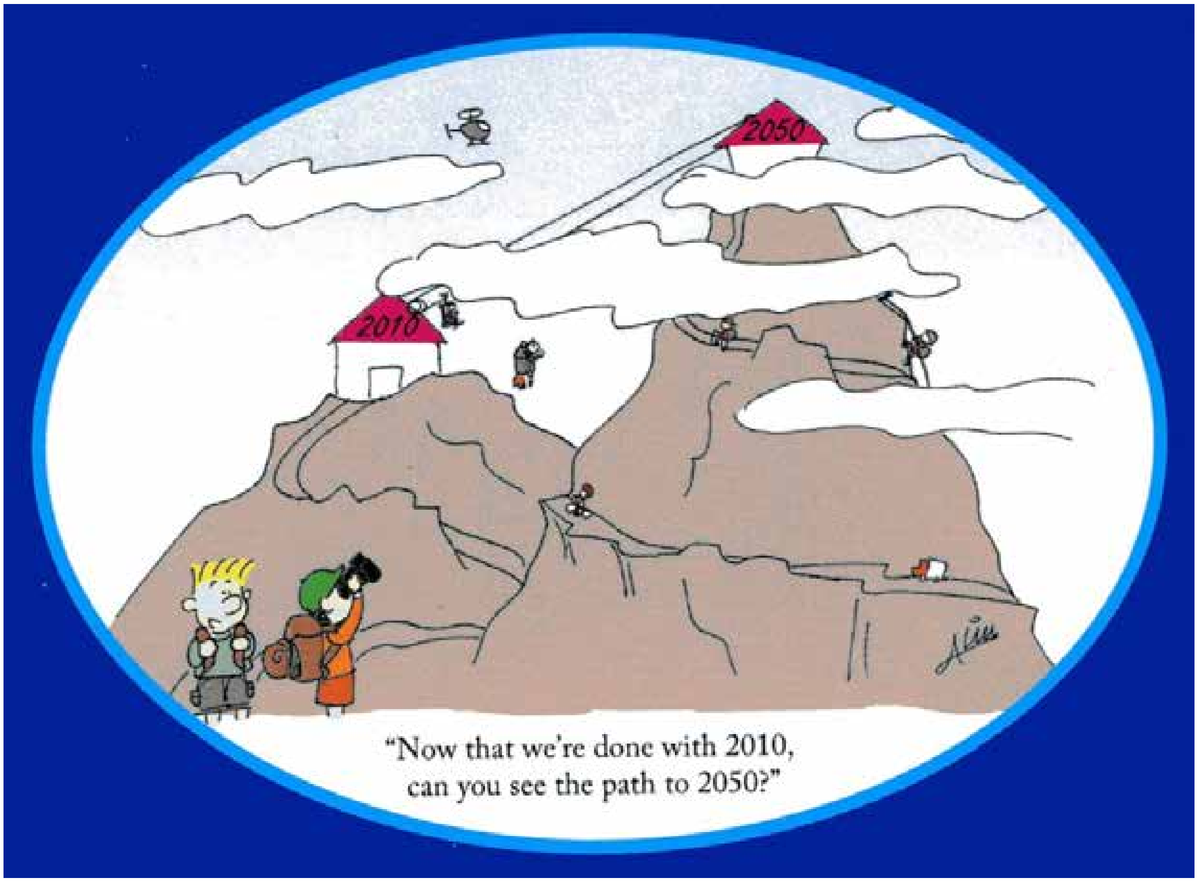
3.0 STATEMENT OF NEED

The state of water resources worldwide is dire. The combined pressures of increasing population, changing weather patterns and pollution will continue to add to the burden of supplying safe water to the world's population for drinking, industrial and agricultural uses. (See appendix A5) The water problem has been an intense focus of study and technology development for a number of years. National labs, Universities, think tanks, environmental groups, international working groups and private industry have all focused on the problems associated with the provision of clean and safe water supplies. This has resulted in a vast body of knowledge and a variety of developed technologies that could be useful in solving global, regional, national and local water problems.

The dilemma is that much of this information is not being disseminated to the end users that could put it into practice to help solve their water problems. Whether this is improved grazing methods to prevent or reverse desertification, more efficient means of irrigation for agriculture, testing for pollutants, resource and water recovery from waste streams, or treatment of specific pollution problems, there are barriers to getting the needed information into the correct hands and putting it in to practice. These barriers can include political (Israeli developers may have a hard time sharing irrigation information with Arab counties), economic (developing countries may not have ready access to the knowledge available due to lack of communications and teaching infrastructure) technological (solutions applicable to industrialized counties may not be practical in developing areas) and social (solutions may not conform to normal social practice). The proposed approach to eliminate these constraints is a World Water Crisis Centre to address key water issues on an ongoing basis under the "New Manhattan Project" initiative of the World Federation of Scientists.

As stated above, the water situation around the world is of very serious concern. However, it is far from hopeless and the many dimensions of the water problems can be solved through concerted efforts of the world water community. The World Water Crisis Centre is designed to take a positive, proactive role in addressing the world's water issues.

- It will draw upon the visions of experts in the field of water from around the world to formulate and implement solutions to these issues.
- It will emphasize practical solutions.
- It will draw from the broad expertise within the World Federation of Scientists to apply emerging technologies
- It will act as a central clearing house and teaching venue for the world's water knowledge for dissemination of information around the world.



Reproduced from *Toward a Sustainable Water Future – Visions for 2050*. (Grayman et al, 2012).

4.0 LEADERSHIP TEAM AND FOCUSED BIOGRAPHIES

For over 35 years the Water Pollution Panel of the World Federation of Scientists has held annual meetings in the "Science City" Erice in Sicily. Each year a prominent list of international scientist has been invited to Erice to work on emerging water centric, Planetary Emergencies.

Academician Lorne G. Everett, PhD, DSc, Chairman World Federation of Scientists Panel on Pollution, Chancellor Emeritus, Gold Medal Russia, Gold Medal Canada, Medal of Excellence US Navy, Honorary Diplomate American Academy of Water Resource Engineers, American Academy of Environmental Engineers- by Eminence, Member Russian Academy of Natural Sciences, co-editor first groundwater maps of the World/UNESCO, author/editor of 14 books on water including Groundwater Monitoring, which was endorsed by EPA as establishing the State of the Art Used by Industry Today and recommended by the World Health Organization for use in all developing countries. Author/editor of Groundwater Resources of the World and Their Use published in Paris, Moscow, Westerville, OH, USA, and translated into different languages. Dr Everett has been Chief Scientist and Sr VP of different multibillion dollar environmental companies. He is President and CEO of L. Everett and Associates, LLC in Santa Barbara Ca, USA.

Dr Frank Parker PhD Civil Engineering Harvard University, Distinguished Professor of Environmental and Water Resources Engineering, Emeritus, Professor of Civil and Environmental Engineering, Emeritus, Vanderbilt University **1967-2010.**

AWARDS

National Academy of Engineering, 1988 – "For world leadership in the development of the basic information required for the safe disposal of high-level radioactive wastes."

Wendell D. Weart International Award

Lifetime Achievement Award in Waste Management, 2003 Third Awardee

American Academy of Environmental Engineers-1998; First engineer elected by "eminence"-

Elected a Fellow of the American Association for the Advancement of Science, 1965

Distinguished Westinghouse Scientist-Professor of Environmental Systems Engineering, Clemson University, 1991-1995

One of 3 Members, Monitored Retrievable Storage Review Commission (MRSRC) - U.S. Congress, 1988-1989

Senior Research Fellow, The Beijer Institute, The Royal Swedish Academy of Sciences, 1984-1987

Senior author of the only 2 Reports cited in the section on radioactive waste in UN Document, (Brundtland) Our Common Future (chapter 7, # 50), 1987

Senior Research Fellow, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1994 – 2007

Director of the Radiation Safety of the Biosphere Section for more than 12 years

Member, Scientific Advisory Council for the International Radioecology Laboratory, Slavutych (Chornobyl)

While a graduate student and then laboratory assistant at Harvard University and in conjunction with the USGS ran the first radioactive tracer studies of mixing in a river (Mohawk)

While at Oak Ridge National Laboratory, and Head of its radioactive waste disposal research section (1) Organized and ran the first radioecological study of a riverine system (Clinch River). The first mass balance of radioactive materials in water, sediments and biota. (2) Took the concept of deep geological disposal of high level radioactive waste to laboratory and full scale pilot study with spent nuclear fuel and reached temperatures and radiation levels that equaled those to be expected in a full scale repository. All such potential disposals today mirror this study. (3) Determined that the Kyshtym Accident, Soviet Union, was an accident at the same time that routine discharges of radioactive material were being made into the Techa River at the Mayak site. The fallout and discharges partially overlapped each other.

Walter M. Grayman, PhD, PE, Diplomate American Academy of Water Resource Engineers, is an independent consulting environmental/civil engineer with over 45 years of experience in the field of water supply and water resources with emphasis on infrastructure, modeling, water quality, GIS and risk/security issues. Dr. Grayman has over 150 publications including co-editor of the recently published book *Toward a Sustainable Water Future: Visions for 2050*, co-author of the book *Modeling Water Quality in Drinking Water Distribution Systems,* and contributing author for McGraw-Hill and Wiley Handbooks on Water Distribution Systems and Water Supply Systems Security. He was the 2013 recipient of the prestigious American Society of Civil Engineers Julian Hinds Award for meritorious contributions to the field of water resources development and has received national awards from ASCE and AWWA for research and service to the profession. He has served as a consultant to the United Nations on water pollution studies in Vietnam, Turkey and Ecuador.

Dan Kroll is Chief Scientist at Hach Homeland Security Technologies and Principal Investigator for the Hach Advanced Technology Group. Dan has 27 years of experience developing technology for the water and wastewater industry. Dan has been the lead researcher on method development projects for the physical, chemical and microbiological quality of water, wastewater and soils for which he holds several patents. His simplified arsenic testing method is used throughout the world as the standard field method to screen for this toxic element. Dan has been awarded the R&D 100 Award for the event monitor trigger system. The award was given for developing one of the world most innovative products in 2005. He is also the author of the book “Securing Our Water Supplies; Protecting a Vulnerable Resource” available from PennWell Publishers. He has authored over 100 book chapters and papers dealing with water technology. He has served on the Federal Technical Advisory Committee for Revision of the Total Coliform Rule and is a member of the International Standards Organization Working Group for Management of Water Utilities. He also serves on the AWWA Standards Committee for Direct Potable Reuse.

Academician Dr. Igor Simonovich Zektser for over 30 was Head of the Russian Academy of Sciences Water Problems’ Institute in Moscow. He has spent his entire career working on water crisis for the former Soviet Union and now Russia. He is the senior author of the groundwater flow map for central and eastern Europe and World Hydrogeologic map. He was written 12 monographs and 220 professional papers on water issues. Dr Zektser is President of the Russian National Committee of the International Association of Hydrogeological Sciences and is a member of many International Academy’s. As an officer of the International Association of Hydrogeologists Dr Zektser can draw from the membership experts.

Dr Alice Aureli, , Coordinator Transboundary Aquifers Management Programme, ISARM, International Hydrological Programme (IHP), Chief Groundwater Systems and Settlements Section, Division of Water Sciences, UNESCO, Paris

Dr Aureli is a hydrogeologist who has worked for 30 years in the UNESCO Water Sciences Division focusing on International water boundary issues. Dr Aureli is the UNESCO lead for the interdisciplinary group that advised the UN International Law Commission in preparing the Articles on the Law of Transboundary Aquifers. Dr Aureli is an expert in Water Security, Groundwater Governance, Impacts of Climate change on Aquifer Systems, Management of Transboundary aquifers and Conjunctive management.

Collaborating Organizations and Scientists, Integrated delivery Team

Russian Academy of Sciences
Institute of Water Problems

The Russian Academy of Sciences Water Problems Institute was established on November 24, 1967 by the order of the USSR Council of Ministers and the resolution of Presidium of the USSR Academy of Sciences. The main scientific activities of the Institute are the study of water resources, regime and quality of surface and subsurface waters, environmental conditions of water projects, problems of water availability for the population of the country, development of assessment methods for changes of water resources under the influence of natural and anthropogenic factors, and management of water resources. The Water Problems Institute focuses on water crisis issues. The Institute is one of the leading Russian research organizations in the field of fundamental research of surface and groundwater resources and their quality. Investigations conducted by the Institute have high international prestige and are highly recognized by Russian and foreign scientists.

THE UNESCO INTERNATIONAL HYDROLOGICAL PROGRAMME

UNESCO's Intergovernmental Scientific Cooperative Programme in Hydrology and Water Resources

United Nations Educational, Scientific and Cultural Organization · International Hydrological Programme

The International Hydrological Programme (IHP) is the only intergovernmental programme of the UN system devoted to water research, water resources management, and education and capacity building. Since its inception in 1975, IHP has evolved from an internationally coordinated hydrological research programme into an encompassing, holistic programme to facilitate education and capacity building, and enhance water resources management and governance. IHP facilitates an interdisciplinary and integrated approach to watershed and aquifer management, which incorporates the social dimension of water resources, and promotes and develops international research in hydrological and freshwater sciences.

IHP-VIII: Water security: Responses to local, regional and global challenges – Aligned with the new eight-year Medium-term Strategy of UNESCO (2014-2021), the eighth phase of IHP (IHP-VIII) was prepared through a comprehensive consultation process with Member States. IHP-VIII will aim to improve water security in response to local, regional, and global challenges. Multidisciplinary and environmentally sound approaches to water resources management will be sought. The role of human behavior, cultural beliefs and attitudes to water, and socio-economic research to better understand and develop tools to adapt to changing water availability are some of the issues to be addressed.

IHP-VIII will bring innovative methods, tools and approaches into play by capitalizing on advances in water sciences, as well as building competences to meet the challenges of today's global water challenges. UNESCO centres and chairs will play an important role in this process.

5.0 SCOPE OF WORK-PROJECT PHASES

5.1 Proposed Approach

The world water crisis is a very broad subject that touches on many specific areas. In order to best address the broad subject, a multi-faceted approach is proposed for the Centre. The approach combines (1) a "top-down" program for addressing selected major subjects directly by the Centre, (2) a "bottom-up" approach for soliciting input from around the world through a series of small external innovative projects, and (3) a forum for generating and communicating information and results to the professional and external lay community.

5.1.2 Top-Down Program

The World Water Crisis Centre will identify specific major water crises for study by the Centre. These topics will result in multi-year efforts within the Centre and for presentation/discussion at the Erice seminar. Initial topics that have been identified include the following:

- Transboundary water issues
- Water scarcity (droughts, water reclamation technologies)
- Water impacts of climate change (sea level rise, water availability)
- Nutrient recovery

See the proposal Appendix for further details on these initial projects.

5.1.3 Bottom-Up Program

A small NGO in Central Africa has an idea for assisting a rural community to procure a safe drinking water supply; A graduate student in the Czech Republic proposes a unique soil moisture sensor; A Professor in Jordan wants to collaborate with counterparts in Israel and Palestine on a water sharing scheme; etc. The bottom-up program at the Centre will fund a series of small innovation grants (typically < 1 year and < $25,000) that address specific solutions to water crises around the world. Principal investigators for the projects will be encouraged to attend the annual Planetary Emergencies Seminar in Erice and present their results at a workshop.

5.1.4 Communications

In order to be effective in addressing water issues and making positive impacts, a mechanism for interacting and communicating with the world community is needed. The Centre will establish several mechanisms to support interaction with water agencies and the public around the world. These mechanisms will be developed in the first year after the Centre is established and may include:

- Attendance and presentations at key conferences (e.g., World Water Forum)
- Establishment of a website and digital newsletter reporting on activities of the Centre
- Planning a session at the annual Planetary Emergencies Conference in Erice with provision for the session to be widely broadcast via the web

5.2 Project and Cost Management

A1:Transboundary Water Issues

Water is widely recognized as an important environmental concern of the 21st century and management of this important resource becomes increasingly more difficult when the resource crosses international boundaries. The fact that hydrologic boundaries and political boundaries generally do not coincide leads to a significant potential for transboundary water issues. Transboundary issues have been widely studied:

Wolf et al. (1999) notes that there are 261 international river basins, covering 45.3% of the land surface of the earth, 145 nations include territory within international basins, and 33 nations have more than 95% of their territory within international basins. [Wolf, Aaron T., et al., International River Basins of the World, Int'l J. of Water Resources Development, Vol. 15, No. 4, Dec 1999].
http://www.tandfonline.com/doi/abs/10.1080/07900629948682?journalCode=cijw20

McKinney (2011) presents a series of transboundary case studies from around the world that highlight the range of issues that are faced in this arena [http://www.caee.utexas.edu/prof/mckinney/ce397/readings/transboundarywaterissues.pdf].

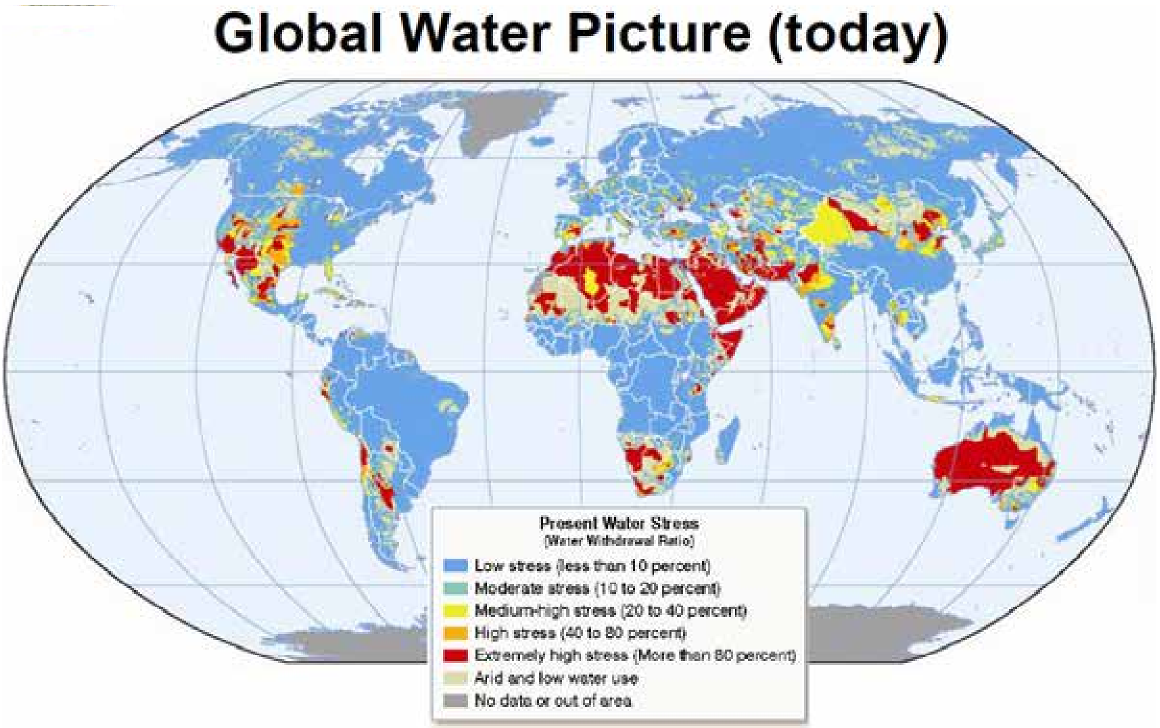
The Guardian (2014) asks the question, "Why Global Water Shortages Pose Threat of Terror and War"? This editorial quotes Peter Gleick, president of the Pacific Institute, "I think the risk of conflicts over water is growing – not shrinking – because of increased competition, because of bad management and, ultimately, because of the impacts of climate change".
http://www.theguardian.com/environment/2014/feb/09/global-water-shortages-threat-terror-war

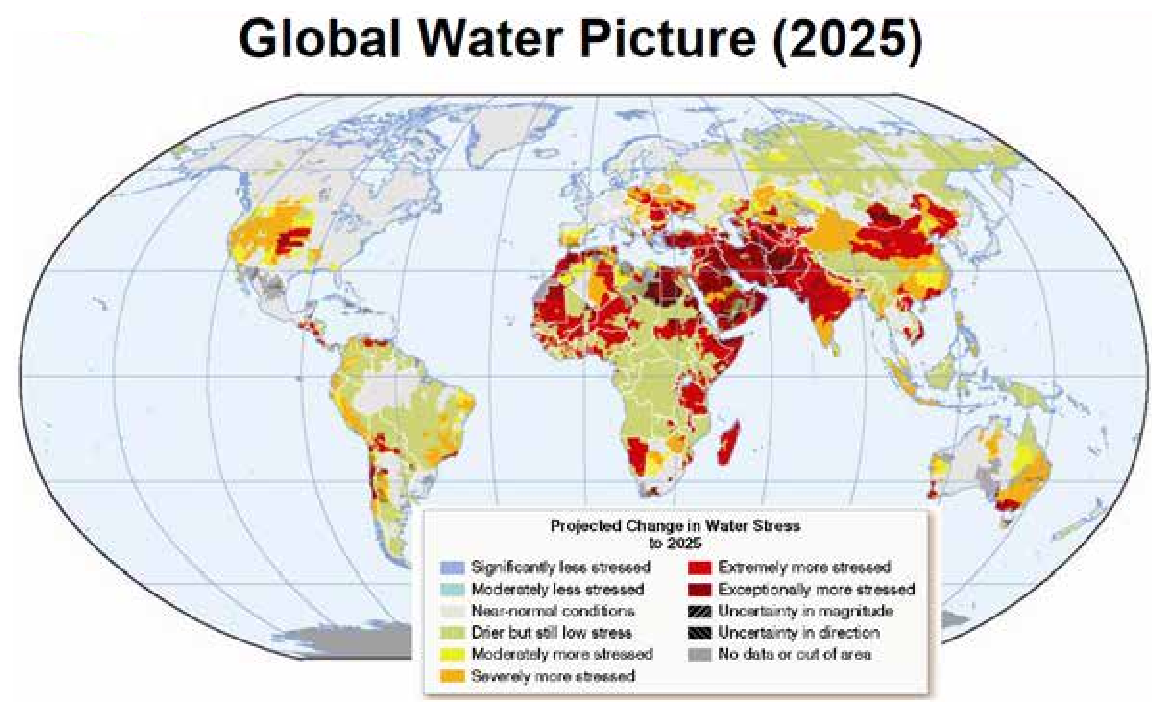
In looking towards the future, Draper (2015) states that "the critical challenge in 2015 will be the same as we face today; to minimize water sharing conflicts through cooperative actions".
http://ascelibrary.org/doi/book/10.1061/9780784412077

Under this initiative, the **World Water Crisis Centre** will become a central forum, focus and information repository for addressing transboundary water issues. Specific activities will be identified in the initial startup phase of the Centre and will likely include:

- A review of information available on transboundary issues
- An initial forum on transboundary issues used to identify specific projects

A2: Global Water Picture: The state of global water stress today is not good.





With increased population, changing weather patterns, pollution and increasing demands for more water as lifestyles and diets change the situation is liable to become significantly worse.

By 2025 significant portions of the globe that are not currently under stress may well be in a situation where the supply of adequate water may become difficult.

A3: Possible Strategies to Reduce Water Stress

From a paper "Wedge approach to water stress" by Yoshihide Wada, Tom Gleeson & Laurent Esnault. Nature Geoscience 7, 615–617 (2014)

"Soft Measures"

1. Agricultural water productivity could be improved in stressed basins where agriculture is commonly irrigated. Reducing the fraction of water-stressed population by 2% by the year 2050 could be achieved with the help of new cultivars, or higher efficiency of nutrients application. Concerns include the impacts of genetic modification and eutrophication.

2. Irrigation efficiency could also be improved in irrigated agricultural basins. A switch from flood irrigation to sprinklers or drips could help achieve this goal, but capital costs are significant and soil salinization could ensue.

3. Improvements in domestic and industrial water use could be achieved in water stressed areas through significant domestic or industrial water use reduction, for example, by reducing leakage in the water infrastructure and improving water-recycling facilities.

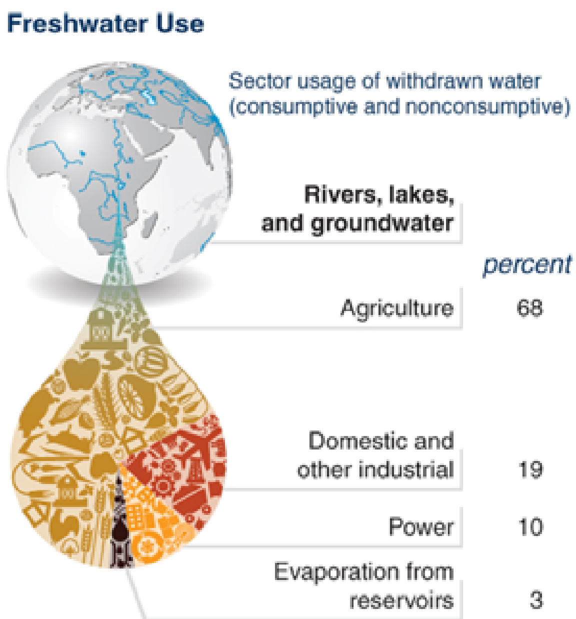
4. Limiting the rate of population growth could help in all water-stressed areas, but a full water-stress relief would require keeping the population in 2050 below 8.5 billion, for example, through help with family planning and tax incentives. However, this could be difficult to achieve, given current trends.

"Hard Measures"

5. Increasing water storage in reservoirs could, in principle, help in all stressed basins with reservoirs. Such a strategy would require an additional 600 km^3 of reservoir capacity, for example, by making existing reservoirs larger, reducing sedimentation or building new ones. This strategy would imply significant capital investment, and could have negative ecological and social impacts.

6. Desalination of seawater could be ramped up in coastal water-stressed basins, by increasing either the number or capacity of desalination plants. A 50-fold increase would be required to make an important difference, which would imply significant capital and energy costs, and it would generate waste water that would need to be disposed of safely.

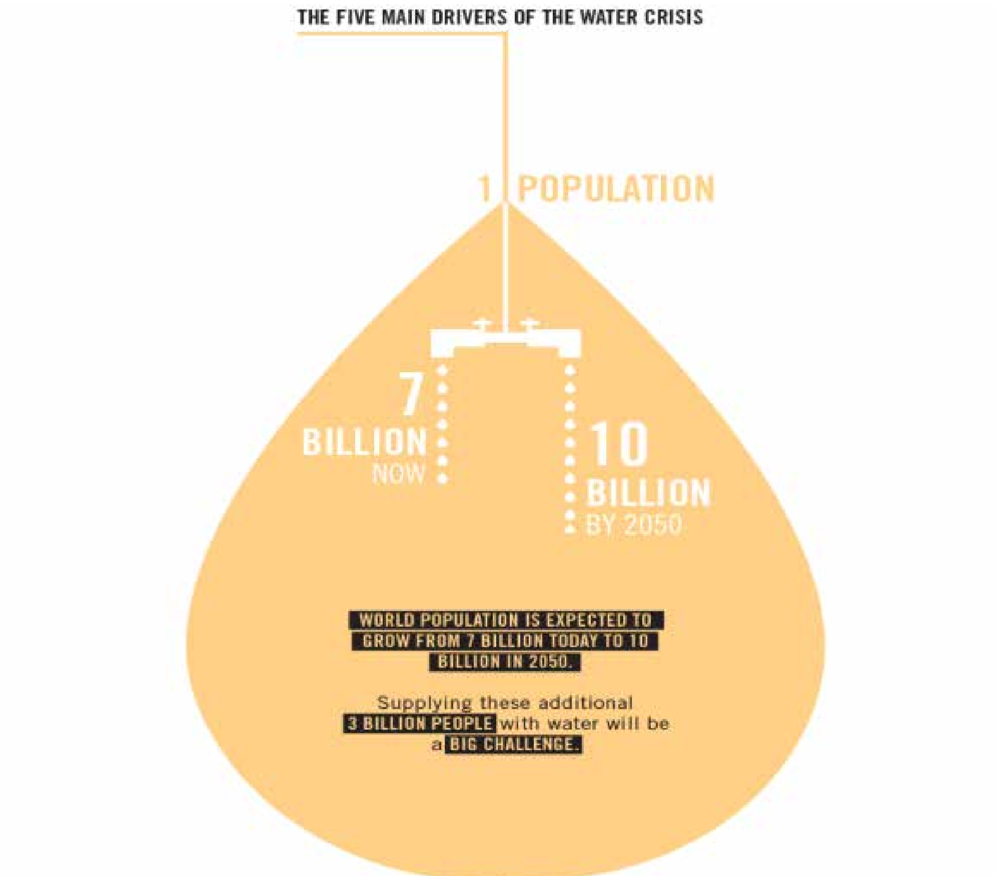
A4: Water and Food Production:

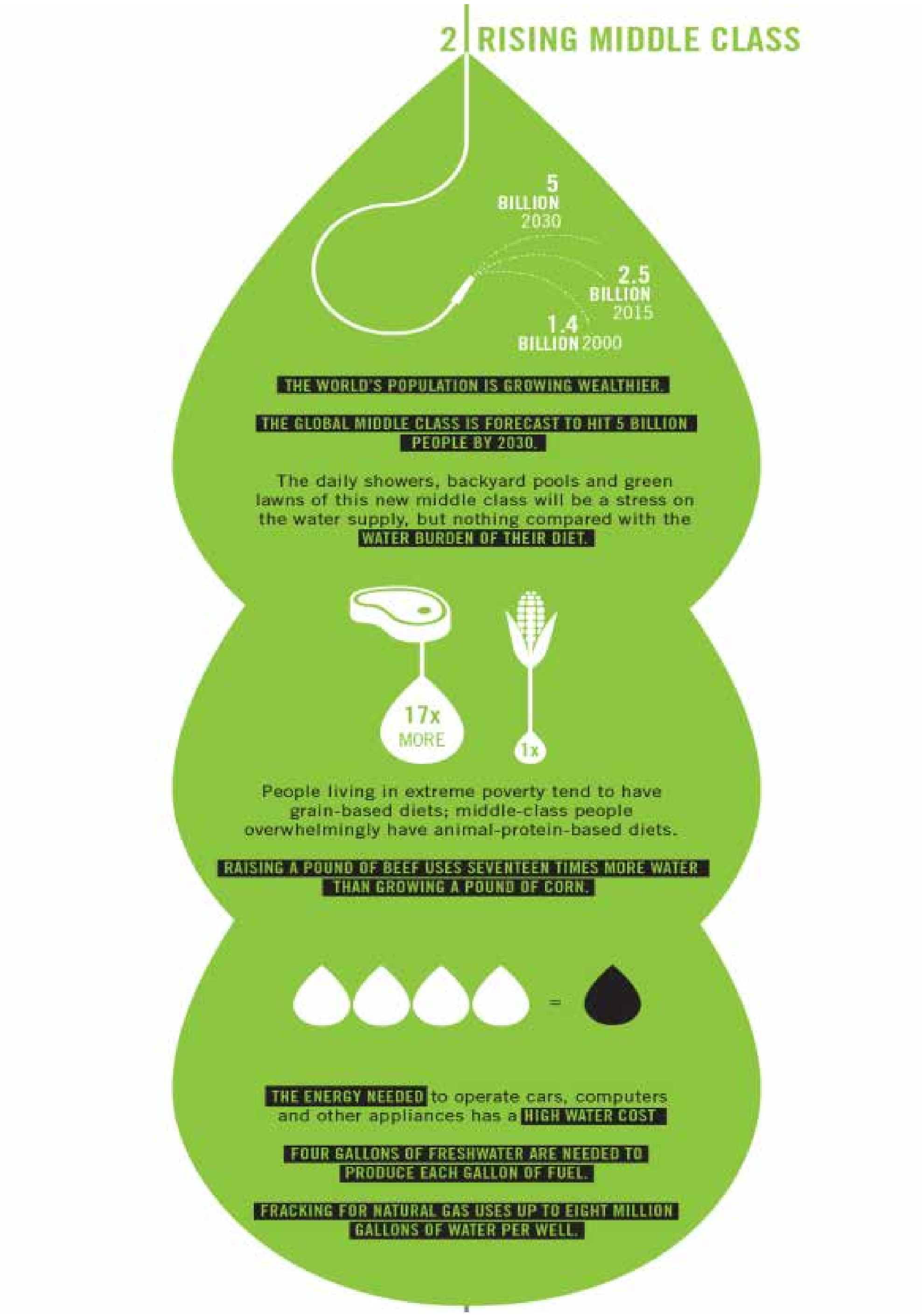


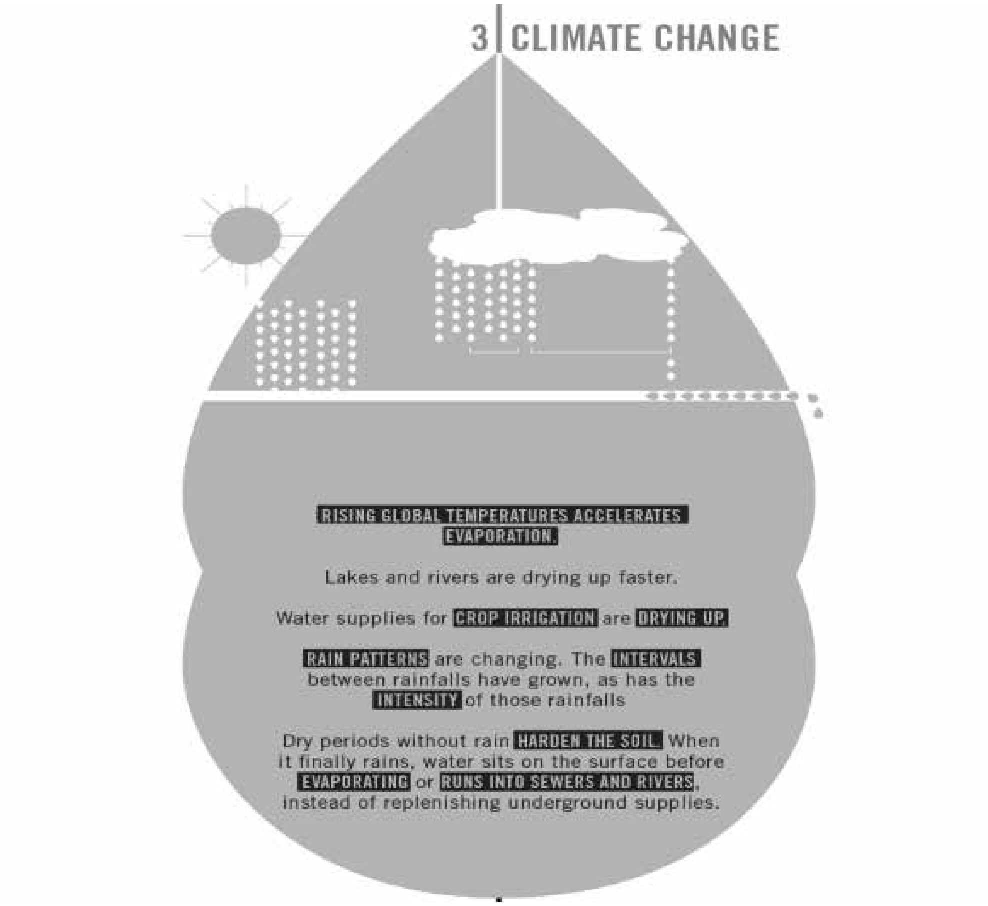
Water Content of Key Food Products

- Maize 900 m^3/ton
- Wheat 1,300 m^3/ton
- Rice 3,000 m^3/ton
- Chicken 3,900 m^3/ton
- Pork 4,900 m^3/ton
- Beef 15,500 m^3/ton

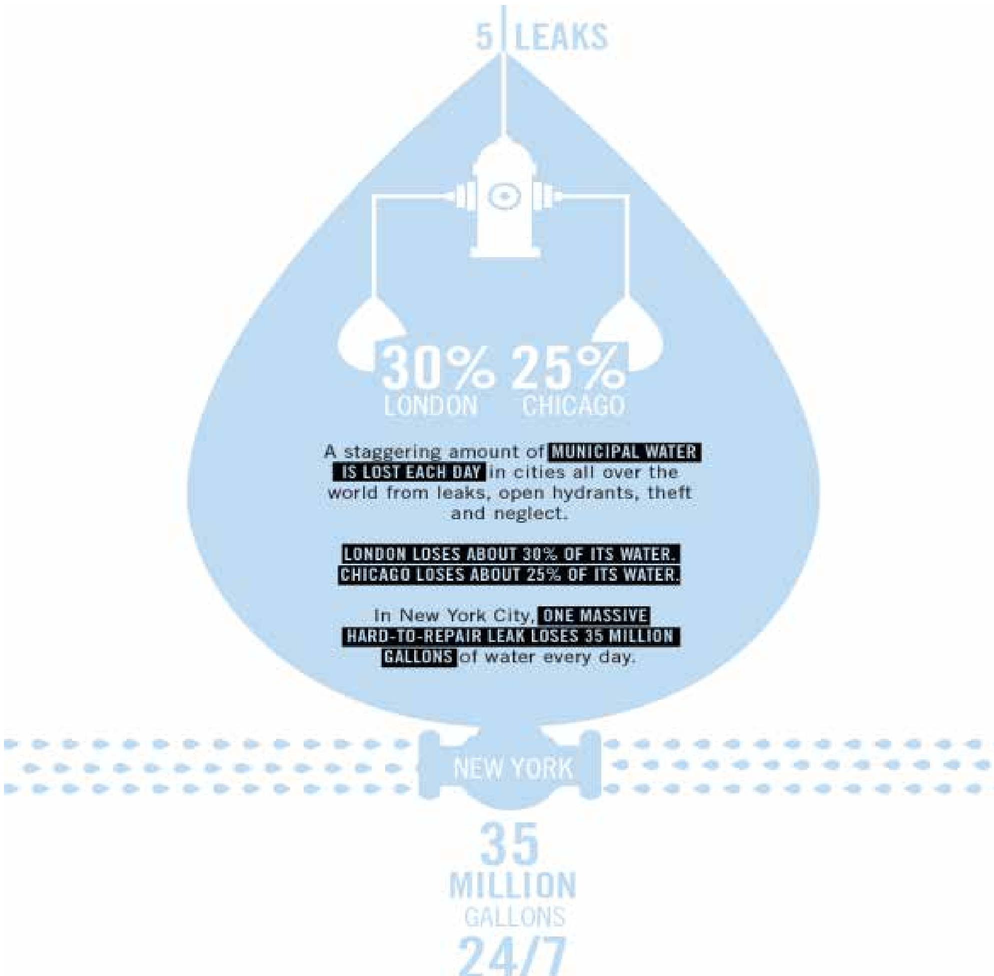
A5: Water Crisis Drivers: There are a variety of compounding conditions that serve to exacerbate the problems facing the world when it comes to supplying adequate amounts of water of an acceptable quality to the population.




2 RISING MIDDLE CLASS
5 BILLION 2030
2.5 BILLION 2015
1.4 BILLION 2000
THE WORLD'S POPULATION IS GROWING WEALTHIER.
THE GLOBAL MIDDLE CLASS IS FORECAST TO HIT 5 BILLION PEOPLE BY 2030.
The daily showers, backyard pools and green lawns of this new middle class will be a stress on the water supply, but nothing compared with the WATER BURDEN OF THEIR DIET.
17x MORE
1x
People living in extreme poverty tend to have grain-based diets; middle-class people overwhelmingly have animal-protein-based diets.
RAISING A POUND OF BEEF USES SEVENTEEN TIMES MORE WATER THAN GROWING A POUND OF CORN.
=
THE ENERGY NEEDED to operate cars, computers and other appliances has a HIGH WATER COST
FOUR GALLONS OF FRESHWATER ARE NEEDED TO PRODUCE EACH GALLON OF FUEL.
FRACKING FOR NATURAL GAS USES UP TO EIGHT MILLION GALLONS OF WATER PER WELL.


3 CLIMATE CHANGE
RISING GLOBAL TEMPERATURES ACCELERATES EVAPORATION.
Lakes and rivers are drying up faster.
Water supplies for CROP IRRIGATION are DRYING UP.
RAIN PATTERNS are changing. The INTERVALS between rainfalls have grown, as has the INTENSITY of those rainfalls
Dry periods without rain HARDEN THE SOIL. When it finally rains, water sits on the surface before EVAPORATING or RUNS INTO SEWERS AND RIVERS, instead of replenishing underground supplies.


4 TAINTED WATER
GLOBALLY, MORE AGRICULTURAL AND INDUSTRIAL CHEMICALS ARE SEEPING INTO THE WATER SUPPLY.
To produce MORE FOOD FOR MORE PEOPLE, MORE FERTILIZER AND PESTICIDE IS USED—MORE OF WHICH IS WINDING UP IN AQUIFERS, LAKES AND RIVERS.
Energy-extraction techniques like fracking not only require the use of large quantities of water, but the chemical additives used in the fracking process are alleged to be POLLUTING NEARBY DRINKING WATER RESERVES.


5 LEAKS
30% LONDON
25% CHICAGO
A staggering amount of MUNICIPAL WATER IS LOST EACH DAY in cities all over the world from leaks, open hydrants, theft and neglect.
LONDON LOSES ABOUT 30% OF ITS WATER.
CHICAGO LOSES ABOUT 25% OF ITS WATER.
In New York City, ONE MASSIVE HARD-TO-REPAIR LEAK LOSES 35 MILLION GALLONS of water every day.
NEW YORK
35 MILLION GALLONS 24/7

6.0 SCHOLARSHIP PROGRAM

The World Water Crisis Centre will require a team of student scholars to work on each water crisis. The scholarship program will draw from Universities around the Globe. The student educational background will be quite broad covering at least: hydrology, water resource engineering, chemistry, agricultural engineering, water reclamation, water purification technology, remote sensing, environmental economics, etc. The program will support 3-5 students per year for 5 years. The students will be selected based on the main water crisis under evaluation during that year.

7.0 PROPOSED PROJECT BUDGET

The following estimated project budget is for a 5-year project duration.

Estimated Project Budget (2017 to 2022)		
Project Phase	**Primary Team Members**	**Range of Funding Required for Completion of Phase**
Development of Comprehensive Plan	Project Manager ($150K/yr) Chief Scientist ($125K/yr) Scientist ($100K/yr) Chief Engineer ($125K/yr) Engineer ($100K/yr) Secretary ($60K/yr)	$350,000-550,000
Establishment of Centre		$375,000-560,000
Plan and Hold Annual Work Shops (5 total)		$180,000-250,000
Stakeholder/Technical Meetings		$100,000-$350,000
Travel Costs		$160,000-$350,000
Student Scholarships		$100,000-$200,000
TOTAL ESTIMATED COST		$1,365,000-$2,260,000

Costs are developed based on US dollar currency for 2016-2017