Summary of Discussions during the International Workshop to Identify Major Scientific and Technical Issues Associated with the Interoceanic Canal through Nicaragua November 10th and 11th, 2014

The Academy of Sciences of Nicaragua invited the InterAmerican Network of Academies of Science (IANAS) and the International Council for Science - Regional Office for Latin American and the Caribbean (ICSU-LAC) to co-sponsor an international workshop to explore scientific and technical issues associated with the proposed interoceanic canal through Nicaragua.

Participating in this workshop were 15 international scientists, as well as Nicaraguan researchers and scientists. Selected by IANAS, these scientists are world experts in the pertinent disciplines, including: biodiversity, conservation, marine biology, limnology and lacustrine ecosystems, civil and environmental engineering, hydrology and hydraulics, public policy, water resource management, water quality, economics, national and international security, and risk assessment.

The main objective of the workshop was to identify and discuss technical and scientific questions pertaining to the Interoceanic Canal Project and sub-projects, to contribute to a public, transparent and well-informed debate.

The expert panel congratulates the Academy of Sciences of Nicaragua for the important role it is playing in promoting science as an instrument of sustainable development. Especially valuable are the Academy's efforts to share in the far-reaching task of providing accurate and timely scientifically based information to decision makers and the Nicaraguan public on this megaproject with multiple ramifications. We encourage the Academy of Sciences of Nicaragua to continue this work and to seek complementary collaboration and support from other international organizations.

The panel encourages adoption of international best practices for the evaluation of megaprojects. These practices include broad and transparent communication with multiple stakeholders to identify opportunities to optimize benefits and to minimize unintended adverse consequences, as well as independent analysis and evaluation of the studies pertaining to feasibility, and technical and environmental impacts.

The panel consolidated its discussions around three general topics: Water and Sediments, Biodiversity, and Socioeconomic Issues. The significance of these issues is multidimensional.

Protecting Nicaragua's natural resources, ecosystems, rich biodiversity and cultural heritage is crucial for the long term viability and sustainability of Nicaragua's economic development.
A nation's biodiversity is a component of its natural capital, the loss of which is irreparable. A project on the scale of this Interoceanic Canal can potentially cause direct and indirect impacts on biodiversity. These impacts must be anticipated, monitored and/or mitigated, before, during and following the construction of the Canal.

Impacts on water and sediments are of concern because Lake Nicaragua is one of the paramount tropical lakes in the world, with profound ecological, environmental, and economic value. All of these attributes could be impacted by an interoceanic canal of this scale and magnitude. The lake has a fragile ecosystem as it is shallow with constantly mixing waters (polymictic); special protection measures are needed to conserve the present good water quality.

The proposed Canal and sub-projects will provide no economic benefit to the nation if the Project ultimately proves to be economically unfeasible. It would be of great relevance to the nation to have in hand an exhaustive cost-benefits analysis, as well as analyses of the effects on national development, human rights, and legal and national security issues.

The panel has identified a number of critically important scientific and technical questions raised by the proposed Interoceanic Canal and sub-projects.

The Proposed Interoceanic Canal and Associated Sub-projects:

Water and Sediments

Lake Nicaragua is unique in its biodiversity, an important natural resource, and a national icon. We identified three especially serious concerns about the impact of the Canal on Lake Nicaragua.

1. Sediment Effects on Water Quality

How are the potential problems associated with sediment resuspension (due to dredging and ship traffic) being considered?

Initial dredging operations, channel maintenance and regular ship traffic are likely to lead to high turbidity, which may adversely affect the productivity of the lake due to a reduction of light penetration. Lake Nicaragua is especially susceptible to the effects of sediment resuspension because it is a shallow (12.5m average depth), polymictic lake (exposed to constant wind action). Sediment suspension could worsen substantially from activities required for an Interoceanic Canal which will cross Lake Nicaragua along 105 kilometers at a depth of 30 meters, according to the present canal design.

Higher turbidity will affect aquatic biodiversity beginning with algae and continuing on to fish, and will also change the composition of organisms living in the sediments and the water-sediment interface. The bottom sediments of a lake have the capacity to store contaminants and nutrients due to their structure and chemical composition, and resuspension will release them to the water column, causing deterioration of the quality of water in the lake.

Among the important contaminants sequestered in sediments are those that demand oxygen. Severe loss of dissolved oxygen leads to hypoxia and fish kills. History shows that Lake Nicaragua has had fish kills in the past, likely due to low oxygen events during periods of low wind mixing. Closely related to hypoxia is eutrophication, the accelerated aging of lakes. Eutrophication will be accelerated by the input of nutrients (N and P) now sequestered in the sediments.

It is important to emphasize that at this time Lake Nicaragua has good water quality; adequate for drinking water, irrigation and other ecosystem services essential to Nicaragua's economy in the future. Introducing contaminants and nutrients into the

water will lower the quality of water considerably and may impair its usefulness. Lake Nicaragua's critical role will be accentuated in the future due to the effects of climate change (drier, warmer conditions), and Nicaragua is among the countries considered to be most vulnerable to climate change. Bioturbation of the sediments causes an increase in eutrophication, which stimulates increased internal nutrient loading from the sediment layers removed and resuspended. Best practices for managing sediments and turbidity will be needed to protect the lake from the worst forms of degradation. Restoration efforts, such as treatment of the lake after degradation, will be much more expensive and possibly unfeasible.

Sediment resuspension is caused by a number of activities. It occurs during channel excavation, dredging and, channel maintenance, and normal navigation. Sediment resuspension is naturally high in polymictic lakes (shallow, windy lakes), but could get much worse with the activities required for a Transoceanic Canal. Resuspension is also greatly influenced by sediment disposal practices during excavation and maintenance dredging.

Hypoxia and Fish Kills

Lake Nicaragua has had fish kills in the past, likely due to low oxygen events during periods of low wind mixing. Sediment resuspension brings large influxes of organic matter into the water column and can increase the likelihood and severity of low oxygen events. (Example: September 2004, Ometepe Island).

Will eutrophication be more severe in the future due to sediment nutrient releases?

Resuspension of bottom sediments changes the quantity and quality of substances in the water. Nutrients and pollutants are rapidly remobilized into the water column and more oxygen is consumed. An increase in productivity is possible, which in turns leads to eutrophication, pollutant bioaccumulation and eventually, a sharp biodiversity decrease, including fish kills.

2. Dredged Materials

How much material will be removed? How will it be removed?

The Canal Project will require dredging of a deep navigation channel through Lake Nicaragua. Excavation and dredging work for the channel will involve removal of hundreds of millions of cubic meters of sediment. This will make it one of the largest

lake dredging operations carried out and will presumably take years to complete. A significant part of the sediment will consist of fine lake deposits.

Dredging can be done hydraulically or by clamshell (or grab) dredging; and these methods can have quite different impacts on turbidity during the dredging process. Even with the most advanced dredging methods, plumes of turbidity will be created; and less advanced methods will produce more suspended sediment.

During normal canal operation, new sediments will be introduced into the channel, and maintenance dredging will be needed throughout the life of the Canal.

Have the quantities of excavated/dredged materials been calculated for the construction phase and the operational phase? During the dredging process, how much dredged material will remain in the water, causing turbidity?

What do the dredged materials contain?

Sediments are the collectors of most contaminants that enter a lake. The contaminants can include metals, nutrients, pesticide, oil and grease. Dredged materials are likely to contain these materials, and this will have a major impact on how the dredged materials can be reused or disposed of. Misapplication of contaminated sediments could affect the lake itself, local agriculture, wildlife, and indigenous and Afro-descendant peoples.

One special concern is the presence of mercury. Lake Managua and Lake Nicaragua have been continuously connected since October 2010. Before this time they were only intermittently connected. Mercury contamination within Lake Managua has spread to the sediments of Lake Nicaragua along with agro-chemical runoff from local farming.

What are the plans for continual monitoring of metals, pesticides, oxygen-demanding substances and nutrients, as well as oil and grease in the sediments to be dredged? Initial data collection should include core samples, bathymetry, stratigraphy, and chemical lithology of the sediments and bedrock beneath the lake. Currently, Nicaragua has the technical and scientific capacity to monitor lake quality and compare it to past research and database information.

Where to put material removed from the lake?

Dredged material is sometimes used to form an island within a lake, or deposited along the route of a canal along the bottom of the lake, or used in other areas within the lake's borders to create new land, for agriculture or parks, for example.

Each approach has its benefits and risks. What is the detailed plan for disposing of, or reusing excavation and operations materials, over the life of the Project? What are the realistic beneficial uses of these materials?

3. Water Quantity: Is there enough water?

In spite of using water-recuperation basins during lock operation, large locks require large volumes of water - water which will be taken from Lake Nicaragua and the proposed artificial lake, Atlanta. This will reduce a significant amount of runoff into the San Juan and Punta Gorda rivers, thus reducing the amount of water needed for other purposes. Therefore, the most fundamental question is whether or not the watersheds will provide enough water today and in the future in light of projected climate change and development?

The San Juan and Punta Gorda rivers will be deprived of a flow of millions of cubic meters per day once the Canal is in operation. The morphology of a river channel is a function of a number of processes and environmental conditions, including the composition and erodibility of the bed and banks; the availability of sediment; the size and composition of the sediment transported through the channel; and not least, the flow rate. With a reduced flow in the San Juan River, the morphology (i.e. the width, depth, slope, sinuosity etc.) of the river will change. The river will respond with deposition of sediment on the river bed and possible narrowing of the width of the river due to encroaching vegetation.

Key Questions

Will there continue to be sufficient water for crop irrigation, domestic water supplies and industrial use? How will the San Juan and Punta Gorda rivers function with reduced flows? Deposition of sediments into the rivers and increased water levels may affect the riparian areas in several ways. For instance, drainage of agricultural areas along the river may be impeded, operation of existing infrastructure (e.g. irrigation intakes) may be hampered; flood risk linked to projected climate change (increase in extreme events) may increase; river navigation may become

more difficult; and drainage to the Indio Maíz Nature Reserve may be affected. Many of the supertankers for which the Canal is being built will likely carry oil and chemicals. Large spills in the lake could be devastating. Chronic continuous release of ship hull chemicals and fuel leaks are long term concerns for water quality and food webs.

Research Needed

Canal and sub-project impact assessments require proper methodology and international criteria in order to bring to light all possible Project impacts. Consideration must be given to climate change and scientific modeling of future scenarios. Current and future water usage and balances should be assessed. Development scenarios such as changes in populations, socio-economic conditions and land use should be considered along with adaptive responses.

Ecological conditions within Lake Nicaragua, including all important ecosystem components: water quality, benthic flora and fauna, fish, mammals and seabirds should be assessed and baselines established. Bathymetric, water currents and circulation studies of the lake are needed. Geologic stratigraphy of the lake bed should be carried out as the proposed channel is much deeper than the lake bed. Lake bed sediment should be analyzed for biological content, oxygen demand, chemical compounds, heavy metals, and mineralogy.

Quantification of impacts should be calculated, and mathematical modeling undertaken to determine possible future environmental impacts from the Canal and sub-projects. Mitigation measures must be explored and set in motion immediately rather than after catastrophic events have occurred.

The Proposed Interoceanic Canal and Associated Sub-projects:

Biodiversity

Nicaragua: A Country with a Wealth of Biodiversity

Biodiversity is the world's natural capital. It is consists of a complex set of inter-related components; genes, individuals; populations; species, ecosystems; and biomes. Nicaragua's biodiversity is extremely rich.

- The proportion of aquatic habitat in relation to terrestrial ecosystems in Nicaragua is very high due to the large size of Lake Nicaragua (8 thousand Km^2).
- The different forest types found across the west-east precipitation gradient contain a high level of biodiversity.
- Nicaragua is within the Transition Zone between Neotropical and Nearctic flora and fauna.
- Nicaragua's Caribbean forests are within the Mesoamerican Biological Corridor.
- Nicaragua's Pacific coast, including Lake Nicaragua, is a migratory bird corridor.
- Nicaragua forms part of the Mesoamerican Biodiversity "Hotspot".
- Lake Nicaragua offers much in the way of artisanal (or small-scale) fisheries and ecotourism, which depend heavily on biodiversity.
- According to experts in Nicaragua, Lake Nicaragua is still in good ecological condition.

1. **What would be the impact of Canal construction and operation on Lake Nicaragua's biodiversity?**
   - The **shallowness** of Lake Nicaragua leaves it susceptible to drastic changes in turbidity via resuspension of sediments, which can cause changes in the food chain.

- During the construction and operation of the Canal in Lake Nicaragua, the **quantity of nutrients in the water column** is likely to increase, which would increase the possibility of algae blooms and possibly the presence of toxic algae in the lake.

- These changes could affect top predators (e.g., fish), and the availability of insects for migratory birds. They could also promote the introduction of damaging aquatic plants and favor more aggressive species such as Tilapia, affecting native fish. Have precautionary measures been contemplated to prevent an increase in aquatic species?

- Since the arrival of **invasive invertebrate species** can be expected in bilge water, have measures for avoiding the dumping or leakage of bilge water into the lake been contemplated?

2. **How would the Project and the creation of Lake Atlanta impact biodiversity on the Caribbean Coast?**

- Since the movement of sediments during canal construction could **affect coral reefs,** and **mangroves and Raphia swamps** in Bluefields, one important question is, has the quantity and quality of the sediments to be deposited along the sea coast been determined.

- The creation of proposed Lake Atlanta (39,500 hectares) could become another focal point for the **introduction of aquatic plant species**. Have there been studies on the species that might become established in this part of the country and will precautionary measures be implemented to detect invasive species in general, including areas neighboring the many new roads?

- Have the types of changes that will occur in the **hydrology of the Punta Gorda** River been calculated? Major changes could affect the biodiversity of the river as well as the surrounding lands.

- To what degree could the **physical barrier** presented by the Canal inhibit animal movement and gene flow along the Mesoamerican Corridor? Have Project organizers considered ways of mitigating this possible impact, such as leaving strips of forest along selected sites close to the Canal border?

3. Secondary effects on biodiversity

- What are the secondary effects on biodiversity caused by human population movement?

- A relevant question is whether or not a **resettlement plan** exists for displaced inhabitants to avoid their eventual resettlement in protected areas. The rate of deforestation in Nicaragua is approximately 70,000 hectares per year (*2010 FAO Global Forest Resources Assessment*), and human migrations could increase this rate when people migrate to protected areas.

- Have Project planners anticipated **cultural and economic changes** which might occur as a result of a possible reduction in native fish in Lake Nicaragua and the Punta Gorda River?

Additional Questions:

- Would Project planners consider an **alternative canal route** from Punta Gorda westward, bypassing Lake Nicaragua? Given that Lake Nicaragua is an important drinking water source, going northward to Corinto rather than entering the lake would allow the Canal to obtain water from both Lake Nicaragua and Lake Managua without contaminating these indispensible bodies of water.

- Would Project leadership consider making their **environmental impact report** available to the public? Distribution of the report would contribute greatly to determining which additional studies are needed. Releasing the report would also invite an exchange of opinions among scientists from different countries and help avoid speculations.

- Given the large number of unknowns, and the particular characteristics of each ecosystem, is a **long-term monitoring plan** - fundamental for adopting timely, adaptive, management measures - being contemplated?

- Have measures for **increasing the number of specialists in the country** - necessary for implementing the monitoring plan - been contemplate.

ACADEMIA DE CIENCIAS DE NICARAGUA

ICSU International Council for Science Regional Office for Latin America and the Caribbean

IANAS INTERAMERICAN NETWORK OF ACADEMIES OF SCIENCES

Proposed Interoceanic Canal and Associated Sub-projects:
Social and Economic Risks to Nicaragua

1. Is the Proposal economically viable?

- Has the Government analyzed the competitive environment, including the possible impacts of technological change, future changes in the cost of oil and shipping, projections of the growth rates of the major world economies and projections of future shipping volumes, and carried out a sensitivity analysis to test the viability of the investment under different plausible future scenarios?

- Under what conditions would the projected revenue from the Canal be sufficient to pay the interest on the capital?

- Would the projected revenue from the Canal be sufficient to pay the interest if the final construction costs are higher than the current estimate of US$40 billion?

- Does the Proposal take account of possible changes in the competitive environment considering both the possible widening of the Panama Canal and the Northwestern passage? How would these developments affect the viability of the proposed Interoceanic Canal?

2. Does the proposal take account of potential risks to national security?

There are two key concerns with regard to national security. One is that criminal organizations utilize many of the same facilities as legitimate business organizations. Drug cartels, Triad gangs, Mafias and other major organized crime networks now ship narcotics, weapons and counterfeit goods through existing shipping hubs. The other is that as trans-shipment hubs play an increasingly crucial role in world trade, they are now at risk of terrorist/cyber-attacks aimed at harming the economic interests of other nations.

- Has the Government ensured that the operator will design the facilities to contain any likely security risk, and invest in screening and scanner technology? Will the Government develop protocols for intelligence-sharing with key partners, and strengthen the capacity to deal with organized crime and terrorism?

ACN Sede UCA –Pabellón 1, 2da Planta.
Tel.: 2278-3923 al 3927, Ext. : 13-68 -1315 / Celular: 8590-7010 / Fax.: 2267-0106
Apartado Postal 69 / Managua, Nicaragua
www.cienciasdenicaragua.org

3. **Is the safety engineering up to the required standard?**

- Have the seismic, eolic, volcanic, and any other pertinent environmental loads been properly characterized in terms of non-exceedance probabilities or return periods?
- Do the Project Design Criteria take account of extreme loading conditions, such as a major seismic event? Have the Canal and critical infrastructure and ancillary work been designed to remain intact before, during and after, under extreme loading conditions?
- Has a transparent and rigorous Peer Review Process been implemented in order to ensure that risks are identified and mitigated, and that the project will maintain the highest practical quality standards during all aspects of conceptual work and design, construction and operation?
- Does the proposal specify robust systems for managing energy, water and environmental impacts, storm and flood controls, and mitigating the risk of water shortages during droughts with adequate storage?
- Does the Proposal allow for the potential impacts of climate change (including drought, storm surge, flooding etc.)?
- Will the Canal developers and operators be required to post a bond or establish a remediation fund or insurance policy to cover the cost of any environmental remediation required?

4. **Will the Project protect human rights and observe all relevant legislation?**

- Will traditional land and water rights of Indigenous Peoples and Afro-descendent communities be respected?
- Will the Project incorporate Articles 5, 89 and 180 of the Constitution of Nicaragua, Laws 28 and 445 of Nicaragua, and ILO Convention 169 and the UN Declaration on the Rights of Indigenous Peoples as to prior, free and informed consent?

- Will these principles be followed in the design, construction and operation phases, and will the Project monitor and report on the potential social and environmental impacts, with particular regard to the possible displacement of people, loss of existing livelihoods and loss of near-extinct local languages?
- Does the Project consider the impacts on displaced populations and resources for those whose land has been expropriated while they await remuneration?
- Will the Project use internationally accepted methods for this monitoring and reporting, and will this process and the results be published and open to peer review?

5. How will the Project affect national development?

- Has the Proposal made provision for large-scale population migration effects?
- Will the Government or the developer be responsible for constructing the houses, schools, clinics, police stations and other infrastructure necessary to support a large workforce during the construction and then the operation phases?
- How will the anticipated economic gains be distributed? Will part of the revenue from the Canal be invested in health and education, especially in the poorest areas?
- What percentage of the jobs created during the construction and operation phases will be local?
- Will an environmental cost-benefit analysis be carried out and published? What methodology will be used to calculate the balance between the benefits of the proposed Project and the value of the environmental assets that may be lost as a result of the development? How will variables such as biodiversity, food and water security and the potential revenue from eco-tourism be valued?

Expert Panel Members
Pedro J. Álvarez, Nicaragua;
Jerald L. Schnoor, USA;
Bruce Rittmann, USA;
Michael Brett, USA;
Víctor Campos, Nicaragua;
Luiz Drude de Lacerda, Brazil;
Kim Wium Olesen, Denmark;
Katherine Vammen, Nicaragua;
Mary T. K. Arroyo, Chile;
Luis Zambrano, México;
Carlos Bicudo, Brazil;
Jean Michel Maes, Nicaragua;
Gerald Urquhart, USA;
Anthony Clayton, Jamaica;
Hernán Chaimovich, Brazil;
Blanca Jiménez, México;
Julio Miranda, USA;
María Luisa Acosta, Nicaragua;
Manuel Ortega Hegg, Nicaragua;
Jorge A. Huete-Pérez, Nicaragua.