

## **REPORT IN REFERENCE TO IDB'S ASSESSMENT AND MONITORING OF SEISMIC RISK IN THE PANAMA CANAL EXPANSION PROGRAM (2027/OC-PN)**

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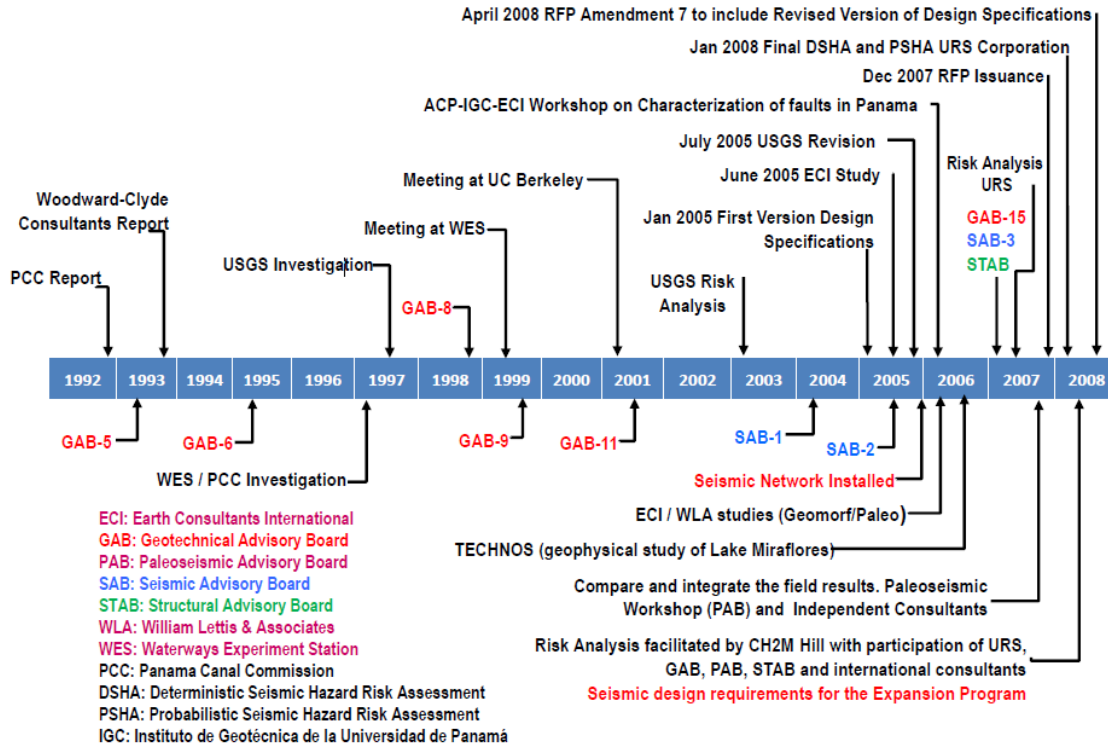
The Bank undertook a thorough review of the seismic risk during project preparation that began in 2007 and concluded that the **Project Risk Classification as it pertained to seismic risk was medium to low**. In addition the Bank also assessed the adequacy of the proposed mitigation measures to manage the seismic risk. During project implementation the Bank has continued to monitor the implementation of measures to manage this risk appropriately. The paragraphs below detail the steps that Management took to assess seismic risk and establish and implement appropriate mitigation.

- i. The Bank identified seismic risk as one of the potential risks in the project and engaged an Independent Engineer ("IE"), the internationally recognized engineering firm Louis Berger, to review all the studies that the Authority of the Panama Canal ("ACP" or the "Borrower") had undertaken over the course of more than 20 years to assess seismic risk in the Canal area (see Annex 1). The IE reviewed more than 36 studies (see Annex 2) as well as reports of the three independent advisory boards of ACP in seismic, geotechnical and structural related topics (see Annex 3) focusing on assessing whether the locks and retaining structures were adequate to mitigate seismic risks. In addition, the Bank asked the IE to review the bidding documents of the locks contract and all the other Expansion Program contracts to ensure that they included adequate design specifications to mitigate seismic risks.
- ii. The Bank specifically asked the IE, among other tasks, to: i) review the design premises and functional specifications for the expansion facilities and any associated facilities, as presented in the Request for Proposal for the Design and Construction of the Locks ("RFP") and other projects within the Expansion Program to ensure that they were complete and adequate to address the seismic and water risks; and ii) review adequacy of the engineering design works in terms of structural, geotechnical and seismic safety, structural durability and operational aspects where applicable.
- iii. The Bank also hired an Independent Environmental Consultant, Environmental Resources Management ("ERM"), to review the Environmental Impact Assessment ("EIA") to identify the level of seismic risk and assess if the mitigation measures, in particular ACP's Contingency Plan ("Rapid Response Program") were appropriate.
- iv. **The level of risk was found to be medium low by the IE and low by ERM, and they both concluded that the mitigation measures for seismic risk were sufficiently robust.**
- v. **The Bank accepted these two expert opinions, and based on these assessments, Management concluded that the Project Risk Classification of the project as it pertained to seismic risk was medium to low and that the mitigation measures were appropriate to adequately manage the seismic risk.**

- vi. In addition, the engineering firm URS, working on behalf of ACP, also confirmed the adequacy of the seismic load included in the design specification of the new locks.
- vii. In terms of mitigation measures, the locks and the retaining structures were designed to withstand a level-1 earthquake (probability of once every 465 years) without obstructing the operation of the Canal or causing damages to the structures holding water; and to withstand a level-2 event (probability of once every 1000 years) with no interference in the structures' ability to permanently hold water.
- viii. Additionally, the Bank set as a condition precedent to first disbursement the requirement that the Borrower present the locks contract to ensure that it reflected the same specifications to mitigate seismic risks that had been previously assessed by the IE as part of the RFP review.
- ix. The Bank in February 2010 reviewed the locks contract and was satisfied that the specifications reviewed by the IE were included in the contract.
- x. During project implementation the Bank has been monitoring the construction works to ensure that the design mitigation measures continue to be implemented as expected during project preparation to adequately manage seismic risk.
- xi. In addition, the Bank has been monitoring ACP's Yearly Contingency Plan Revision and Updates for the Expansion Program. For the operation of the new works, the Bank will monitor that ACP's Contingency Plan be appropriately revised to include the new structures, an analysis of the new risks, and the identification of responses to these new hazards.
- xii. The Bank's monitoring of these issues is facilitated by the fact that ACP has a Geotechnical Engineering Risk Management Department that manages programs for Seismic Vulnerability and Dam Safety, and the Seismic Vulnerability program has a network of accelerographs and seismographs compiling data daily.
- xiii. In addition, ACP also supervises the Expansion Program construction with the support of CH2M Hill, another highly regarded international engineering firm.

# Annex 1

## Chronology of the Seismic Hazard Characterization of the Canal Area and Expansion Program Design Specifications



## Annex 2




### Seismic studies, reports, design specifications and plans reviewed by the Independent Engineer

- Panama Canal Commission Report, 1992
- ACP Report, 1992
- Informe de los consultores Woodward-Clyde, 1993
- Waterways Experiment Station/ Panama Canal Commission Investigation, 1997
- US Geological Service, 1997, Study Investigation
- US Geological Service, 2003, Study Risk Analysis
- CPP, 2003, Conceptual Design Post Panamax Locks
- USACE, July, Panama Canal Concept Design – Atlantic Lock Structures- Third Lane Project
- ACP, 2003, Comparison of One 3-lift lock with one 1-lift Plus one 2 lift lock at the Pacific Side
- ACP, 2003, New Locks Alignment at the Pacific Side Alignment PMD
- Adequacy of Selected Lock Size Parameters for Expanded Panama Canal, Hans Payer, 2005
- Consorcio Post-Panamax, 2005, Alternative conceptual design of Pacific and Atlantic Post Panamax locks - 3x2 Water savings
- ACP Memorandum of Seismic Design Criteria, 2005
- Earth Consultants International, 2005
- Social Enterprise Consulting, 2005, Design value management, constructability dialogs, and risk assessment
- Informe Del Consultor-Campbell R Harvey, 2005
- Enterprise Risk Management, 2005, Panama Canal Risk Assessment Report
- CCP, 2005, Update the Pacific Locks Conceptual Design and Harmonization of the Atlantic Locks Conceptual Design
- US Geological Service, 2005
- Earth Consultants International, 2006, Geomorphic Evaluation of the Miraflores, Pedro Miguel, Azota and Caballo Faults
- TECHNOS Inc, 2006, Geophysical Investigation for the third Set of Locks Project
- ACP, 2006, Relevant Information on the Third Set of locks Project
- ACP, 2006, Plan Maestro del Canal de Panamá
- ACP, 2006, Proposal for the Expansion of the Panama Canal Third Set of Locks
- ACP Expert Technical Committee, 2006, Development and implementation of a risk model and contingency estimation for the Panama Canal Expansion Program
- ACP, 2006, Development and implementation of a risk model and contingency estimation for the Panama Canal Expansion Program,
- URS, 2007, Seismic Criteria Study
- Earth Consultants International, 2007, Paleoseismic Trenching of the Pedro Miguel Fault in the Cocoli
- Earth Consultants International, 2007, Quantitative Characterization of the Pedro Miguel Fault, Determination of Recency of Activity on the Miraflores Fault, and Detailed Mapping of the Faults through the Proposed Borinquen Dam Location

- William Lettis & Associates, 2007, Paleoseismic Evaluation of the Pedro Miguel, Rio Gatun and Limon Faults
- URS, 2008, Development of Design Earthquake Ground Motions
- URS, 2008, Characterization of Fault Displacement Hazards. Design of the Borinquen Dams
- Earth Consultants International, 2008, Quantitative Determination of the Pedro Miguel Fault slip displacement and slip kinematics for the design of the Panama Canal Expansion Project Borinquen Dam
- ACP, 2008, Technical Consulting Services for the Panama Canal Expansion Program
- ACP, 2008, Design and Construction of the Third Set of Locks
- ACP, 2008, Summary of the Excavation Design for the South End of the Pacific Approach Channel

# Annex 3

## Board of Consultants

Geotechnical Advisory Board	Seismic Advisory Board	Structural Advisory Board
 <p>Dr. Norbert R. Morgenstern Professor of Geotechnical Eng, University of Alberta</p>	 <p>Dr. Robert L. Wesson Senior Geophysicist, USGS</p>	 <p>Dr. Robert Hall Retired Chief, Geosciences &amp; Structures Division, WES, USACE</p>
 <p>Dr. James Michael Duncan Professor of Geotechnical Eng, Virginia Tech</p>	 <p>Dr. Paul Sommerville Principal Seismologist, URS Corporation, Pasadena, CA</p>	 <p>Dr. Anil Chopra Professor of Structural Dynamics, UC Berkeley</p>
 <p>Dr. Robert L. Schuster Retired Geotechnical Engineer &amp; Geologist, USGS</p>	 <p>Dr. Julian Bommer Professor of Earthquake Risk Assessment, Imperial College, UK</p>	 <p>Dr. Sam X. Yao Chief Engineer, Ben C. Gerwick, Inc., San Francisco, CA</p>
 <p>Dr. William F. Marcuson Retired Chief, Geotechnical Laboratory, WES</p>	 <p>Dr. Farrok Nadim Director, International Centre for Geohazards , Norwegian Geotechnical Institute</p>	 <p>Dr. Enrique Matheu Chief, Dams Sector Branch, Department of Homeland Security, Washington, DC</p>
 <p>Dr. Robert L. Wesson Senior Geophysicist, USGS</p>	 <p>Dr. Lloyd Cluff Director, Earthquake Risk Management, Pacific Gas and Electric Co., San Francisco, CA</p>	 <p>Dr. José Roesset Professor of Structural Mechanics &amp; Dynamics, Texas A&amp;M</p>
		 <p>Dr. Martin Wieland Structural Engineer, Pöyry Energy Ltd., Zurich, Switzerland</p>