



# **Panama Canal Study to Increase Draft**

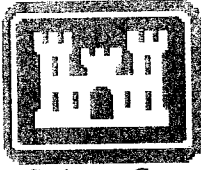
## **Estudio para Aumentar el Calado en el Canal de Panamá**

**USACE**

**11 de abril de 2002**

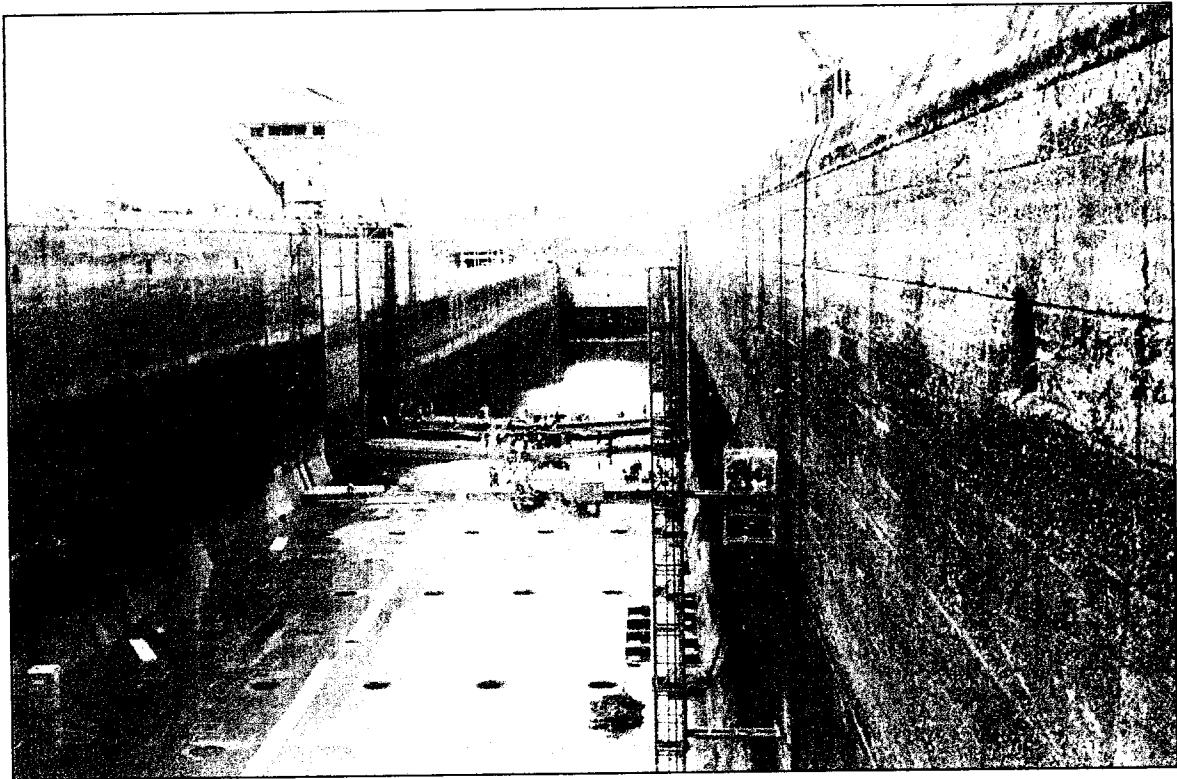
**Contrato No. 62000**

**Propósito, Recomendaciones y Conclusiones  
(No existe Resumen Ejecutivo)**



U.S. Army Corps  
Of Engineers  
Pittsburgh District

## PANAMA CANAL STUDY TO INCREASE DRAFT



**FINAL REPORT  
11 APRIL 2002**

*Pending final  
Comments from  
ACP.*

# PANAMA CANAL STUDY TO INCREASE DRAFT

## 1. Purpose

The Panama Canal Authority is interested in increasing the allowable draft of vessels through the canal in order to increase canal capacity. At the present time, the maximum draft of 12.04 m (39.5 ft) is limited by the water levels in the lakes and lock chambers and the elevation of the miter gate and caisson sills. The purpose of this study is to evaluate alternative measures that would increase vessel draft beyond the existing 12.04 m (39.5 ft) limitation. The two basic alternatives considered are raising the water levels in Gatun and Miraflores Lakes and lowering critical sill elevations in the locks. Increasing lake levels would necessitate adjustments to the entrance velocity of the lake chambers or to certain features of the locks such as the tops of the miter gates and openings in machinery recesses. These features were evaluated, structural modifications are defined and a maximum practical increase in lake levels is recommended. Likewise, the various gate and caisson sills are evaluated to determine which sills are critical in limiting vessel draft. It was initially established during a site visit to Miraflores Locks on 22 September 1999 that the maximum extent of sill lowering permitted would be that which did not require adjustment of the pintle base. Based on the site inspection in 1999, it was determined that the critical sills could be lowered 305 mm (1 ft). Preliminary designs are prepared to lower the critical sills to the recommended elevations and various methods of demolition and construction are considered. Estimated costs and construction schedules are developed for the various alternatives to enable to ACP to evaluate the economic impacts of performing the work.

## 2. Methodology

There are two means of increasing the vessel draft – raise Gatun and Miraflores Lakes and lower the sills of the locks. The study focused on identifying the critical structural elements within the locks that placed limits on raising the lakes and lowering the sills. A threshold established at the onset of the study is that no or only minor structural modifications are required of the lock elements for each alternative evaluated. The limit placed on lowering the sills is that modification of the chamber floors and the pintles of the miter gates is not an option. The limit placed on raising the lake elevations is that flooding of machinery recesses and galleries is not permitted.

The identification of the critical sills is based on ACP Dwgs. 6832, 6124-6, 7039, 7041-2, 7045, and 7065-7, the ACP plates entitled “Master Miter Gate and Valve Overhaul Schedule”, “Panama Canal Elevations Diagram”, and “Under keel Clearance and Over the Sill Clearance for 39.5 Feet Draft Vessels”. All of the material was compiled to develop Plate 1 (Appendix 1). Plate 1 served as the basis for identifying the critical sills.

The basis of determining the elevation in which the critical sills may be lowered was a site visit to Miraflores Locks on 22 September 1999 and a review of the aforementioned drawings and ACP Dwgs. 5023, 5025, 5088-223A, 5158, and 5161. The miter gate seals and sills were

Miraflores Upper West Lock” dated 30 June 1999. For the purpose of this report, a 76 mm (0.25 ft) raise in pool at Miraflores Lake is proposed and analyzed including wave actions. These effects are analyzed and compared with a baseline condition of 16.61 m (54.5 ft) lake level for Miraflores. A similar situation is presented for Pedro Miguel and Gatun.

As presented in Table 8, the expected surcharge from waves exceeds both critical elevations at all lake chambers. This phenomenon can be confirmed by observation quite frequently during normal lockage operation. Measures have already been implemented to limit flooding of the bull gear pits by partially closing the slots utilizing a flexible material in some locations.

**Table 8. - Downbound Entering From Lake Maximum Surcharge Wave Estimates - Raise Gatun and Miraflores Lakes 76 mm (0.25 ft) and Lower Critical Sills 305 mm (1 ft).**

<u>Miraflores</u>	<u>Draft</u> (m) (ft)	<u>Pool El.</u> (m) (ft)	<u>Aship</u> (m <sup>2</sup> ) (ft <sup>2</sup> )	<u>Atotal</u> (m <sup>2</sup> ) (ft <sup>2</sup> )	<u>BR' *</u>	<u>Vmax **</u> (m/s) (ft/s)	<u>Expected Surcharge</u> (m) (ft)	<u>Expected Elevation</u> (m) (ft)	<u>Maximum Surcharge</u> (m) (ft)	<u>Maximum Elevation</u> (m) (ft)
Baseline	12.04 39.5	16.61 54.5	385.1 4145	464.8 5003	0.829	0.69 2.27	0.92 3.03	17.54 57.53	1.11 3.63	17.72 58.13
Raise lake + Lower sill	12.04 39.5	16.69 54.75	385.1 4145	477.5 5140	0.806	0.74 2.43	0.80 2.63	17.49 57.38	0.98 3.23	17.67 57.98
Raise lake + Lower sill + increase draft	12.42 40.75	16.69 54.75	397.3 4276	477.5 5140	0.832	0.68 2.24	0.94 3.10	17.63 57.85	1.13 3.70	17.82 58.45
Raise lake + Lower sill + increase draft + limit speed	12.42 40.75	16.69 54.75	397.3 4276	477.5 5140	0.832	0.64 2.11	0.84 2.77	17.53 57.52	1.03 3.37	17.71 58.12
<b><u>Pedro &amp; Gatun</u></b>										
Baseline	12.04 39.5	26.67 87.5	385.1 4145	536.6 5776	0.718	0.94 3.09	0.52 1.71	27.19 89.21	0.70 2.31	27.37 89.81
Raise lake + Lower sill	12.04 39.5	26.75 87.75	385.1 4145	549.4 5914	0.701	0.98 3.21	0.49 1.60	27.23 89.35	0.67 2.20	27.42 89.95
Raise lake + Lower sill + increase draft	12.42 40.75	26.75 87.75	397.3 4276	549.4 5914	0.723	0.93 3.05	0.53 1.75	27.28 89.50	0.72 2.35	27.46 90.10
Raise lake + Lower sill + increase draft + limit speed	12.42 40.75	26.75 87.75	397.3 4276	549.4 5914	0.723	0.83 2.73	0.45 1.46	27.19 89.21	0.63 2.06	27.37 89.81
* Equations from <u>Measurement of Pressures Related to Vessel Movement within Miraflores Upper West Lock</u> , by Raymond A. Povirk and Raymond D. Rush, Pittsburgh District, U.S. Army Corps of Engineers, June 30, 1999										
# Vmax is the maximum expected velocity for a given modified blockage ratio (BR') based on measurements at Miraflores Upper West Lock										

#### 4. Recommendations

Based on the results of this study, the following recommendations are made:

- Raise Miraflores Lake by 76 mm (0.25 ft) to EL +16.69 m (+54.75) from EL +16.61 m (+54.5 ft).
- Raise Gatun Lake by 76 mm (0.25 ft) to EL +26.75 m (+87.75) from EL +26.67 m (+87.5 ft).
- Lower the elevation of the Sills for Miter Gates Nos. 13-20 for Gatun Locks and for Miter Gates Nos.54-69 for Pedro Miguel Locks by 305 mm (1 ft).

- Modify the bottom of the miter gates of the critical sills - Miter Gates Nos. 13-20 for Gatun Locks and for Miter Gates Nos.54-69 for Pedro Miguel Locks.
- Lower the chain fenders sills of Pedro Miguel by 305 mm.
- Lower the emergency dam sill of Miraflores Locks by 530 mm.
- Decrease the entrance velocity of the ships by 0.05 m/s (0.16 ft/s) for the lake chambers of Miraflores Locks to 0.64 m/s (2.11 ft/s) from 0.69 m/s (2.27 ft/s) [Table 8].
- Decrease the entrance velocity of the ships by 0.11 m/s (0.36 ft/s) for the lake chambers of Gatun and Pedro Miguel Locks to 0.83 m/s (2.73 ft/s) from 0.94 m/s (3.09 ft/sec) [Table 8].

## 5. Conclusions

Based on the cost estimates for modifying the critical miter gate sills and gates, and the results of the wave surcharge evaluation for raised lake levels, we recommend: 1) raising both Gatun and Miraflores Lakes by 76 mm (0.25 ft), 2) lowering all critical sills by 305 mm (1 ft) with the exception of the emergency dam sill of Miraflores Locks, it should be lowered 530 mm (1.75 ft) to place it at the same elevation as the upper lake sills, and 3) reducing the entrance velocity of vessel to mitigate wave surcharge. These modifications will result in an increase in draft of 381 mm (1.25 ft), from 12.04 m (39.5 ft) to 12.42 m (40.75 ft). Raising the lake levels and lowering the critical sills will result in an increase in draft of 3.2 pct. Determination of the benefits and disbenefits that would result from the increase in allowable draft is outside the scope of this study. The US Army Corps of Engineers recommends that the PCA: 1) assess the impact of raising Miraflores and Gatun Lakes on the dams, shoreline structures, and other structures, 2) investigate the operational feasibility of raising and maintaining the recommended lake levels, and 3) estimate those benefits and using the costs herein to determine the economic feasibility of further developing these concepts into plans and specifications.