# Panama Canal Concept Design of Atlantic Locks Structure Third Lane Lock Triple-Lift Configuration

# Diseño Conceptual del Canal de Panamá Estructura de Esclusas del Atlántico Tercera Vía Configuración de Tres Niveles

**USACE**

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**Resumen Ejecutivo**

# 1. EXECUTIVE SUMMARY

Appendix N is a subset of the Main Report and follows the intent of Modification No. 2 to IAPWO No. SAA-80640, Changes to the Scope of Work, issued by the ACP on January 24, 2003. The primary deliverables specified in Modification 2 include a Lock Screening Study report of four alternate configurations for a double-lift lock, reconfiguration of the double-lift lock concept designs, selection of a filling and emptying system for the triple-lift lock, and a preparation of a construction cost estimate for a triple-lift lock. The Lock Screening Study was submitted in February 2003 and was included as Appendix J - Filling and Emptying System Screening Study in the Double-Lift Concept Design Report that was submitted in March 2003. The ACP provided guidance to the USACE design team to proceed on the triple-lift lock using an In-Chamber Longitudinal Culvert filling and emptying system and to explore the A-1 Alignment as a candidate site in March 2003. This appendix provides a cost estimate for a triple-lift lock based on a design performed to a level that assures safe and reliable operation.

This Appendix presents the concept level design for a single triple-lift structure lock configuration through abbreviated narratives, drawings, design calculations and cost computations. This design shows that the locks are constructible within the A-1 Gatun site using conventional construction techniques. In-the-wet construction techniques would be needed to construct the Gatun Lake entrance walls in the most efficient manner. This construction practice has been used successfully on several recently constructed locks and dams built by the US Army Corps of Engineers. The siting of the locks provides safe and efficient traffic management. The estimated first-cost for the construction of the lock is $1,080,000,000. The estimated construction time for the completion of all features is 5 1/2 years. This can be reduced as discussed below.

## 1.1. Project Features

This is a brief overview of the evaluation, conclusions reached, and the recommendations for the major project features. A summary of the main features is as follows:

### 1.1.1. Lock Gates

The mitering gate is the recommended gate type for use in the Atlantic Locks. Operation of the gates would be accomplished using direct-connect hydraulic cylinders similar to those being installed on the existing locks. Two methods for handling the gates for maintenance were developed and presented in the Main Report. A complete discussion on the evaluation of gate alternatives is presented in Appendix B – Gate Section Study.

Only two different gate designs are needed for the triple-lift lock. The Gatun Lake gates would be 22.34 m tall and the other gates would be 30.43 m tall. The total weight of all gates would be approximately 24 000 t including contact blocks and embedded metals. As with some gates owned and operated by the US Army Corps of Engineers, the gates could be sectionalized such that a lower section of the taller gates could be used as lake gates to minimize spare gate components.

An emergency closure system capable of closing open channel flow from Gatun Lake through the new Third Lane Locks is recommended as a project feature. This structure would be located upstream of the Gatun Lock Gates. The use of single gates as opposed to double lock gates may be justified as an additional cost saving measure in consideration of the protection offered by an emergency closure system and implementation of quick gate change out systems. Cost reduction could be realized in gate fabrication, masonry construction, operating equipment, and reduced length of in-the-wet entrance wall construction.

### 1.1.2. Lock Structure Alignment

The triple-lift lock structure alignment was optimized both longitudinally and transversely through a progressive process of studying various alignments and angled possibilities. Due to the length of the triple-lift lock and limited size of landmass in proximity, a waiver from the Scope of Work was requested and received to place the lock along the A-1 alignment. This alignment is at the best-fit location to use the geologic stratigraphy of the Gatun site and pre-excavation performed in 1939, which reduces the excavation costs. The recommended alignment is at an angle of 7.9-degrees from the Atlantic entrance channel. It has only a minor impact on the Gatun Lake mooring and boat facilities. The offset of the alignment with the addition of water saving basins provides sufficient distance to the side of the channel entry from the Atlantic Ocean and Gatun Lake to safely manage ships entering and exiting the existing and new locks. The additional separation between the existing locks and new locks provided by the A-1 alignment may also provide benefits from a security risk perspective.

### 1.1.3. Filling and Emptying System

In accordance with Modification 2 of the Scope of Work, the in-chamber longitudinal culvert system (ILCS) was adopted for the triple-lift design. Because the selected filling and emptying system was predetermined, a detailed screening analysis of alternatives was not performed. A brief summary of some considerations and recommendations related to the triple-lift configuration is presented in the following paragraphs. Additional information is presented in Section 2.5 of this report and details are provided in Section 11 of Attachment 2 - Hydraulic Analyses and Design.

The ILCS system has the culverts located longitudinally along the lock floor. The filling and emptying system with water conservation features (water saving basins) are designed as a combined system to operate together and provide the required fill/empty time of about 8-10 minutes. The filling and emptying system was also designed to minimize impacts for operations without water saving basins. Performance under maintenance conditions was also evaluated. The ILCS design provides equalization times ranging between 6.8 and 8.4 minutes for operations without water saving basins. Equalizations with use of water saving basins are expected to range between 9.5 and 10.3 minutes. Hawser forces will be within acceptable limits and slightly lower than the ILCS system for the double-lift design. The filling and emptying system is expected to perform adequately for the triple-lift configuration and is compatible with other recommended design features. The system is designed to operate safely and efficiently with water saving basins during normal operation. Hydraulic performance may be slightly degraded for the ILCS when operating under maintenance conditions due to potential loss of symmetry.

The USACE recommends that the interlaced bottom lateral filling system should be given serious consideration in any future studies of the triple lift. It would provide improved performance over the ILCS system, especially under maintenance. Based on comparison studies of the double lift, the difference in cost between the two systems is expected to be low. Limited information pertaining to the bottom lateral system for the triple-lift arrangement is included in Attachment 2 - Hydraulic Analyses and Design.

#### 1.1.4. Lock Walls

The lock walls have been designed considering the related features, with space provided for locomotives as the ship-positioning system, and provide the most economical solution for the integration of the project features. The water saving basins are located on the West side of the lock and are integrated spatially (non-structural) into the back of the walls. The valve operation monoliths are incorporated into the walls and basins. The culverts have been removed from the walls except as required to accommodate culvert valves. The lock walls are gravity monoliths founded on rock. Roller compacted concrete is used extensively for economy of construction of the lock walls; conventional concrete is used in the areas of culverts, galleries, the lock chamber face and the top surface and land side of the monoliths. The lock walls and water saving basins contain 3 930 000 $m^3$ of concrete of which 1 115 000 $m^3$ is cast-in-place concrete and 2 815 000 $m^3$ of roller compacted concrete. Aggregates for concrete would come from the Pacific excavation and likely be delivered by rail to the Atlantic lock site. Earthquake event loading is the controlling load case. Space is provided at the top of walls to include a ship positioning system similar to the existing locks. The lock gate monoliths would be constructed as conventional gravity structures founded on a rock foundation.

#### 1.1.5. Entrance Walls

These walls present a special condition because of the size of the impact loads that would be transmitted by the large Post-Panamax ships. Loads developed based on discussion with the Canal pilots were considered and found to be excessively high. Criteria for ship impact was developed and is based on consultation with fender manufactures and PIANC design recommendations. However, a detailed investigation should be performed before final design to define the necessity and magnitude of these loads. The wall length represents one and one-half ship length as requested by the Canal Capacity Projects Office. The Atlantic entrance walls would be constructed on roller compacted concrete and the Gatun entrance walls would be cast-in-place concrete cap walls founded on a drilled shaft foundations and would be constructed for the most part in-the-wet using specialized construction techniques. If tugs are used to manage the ships in the lock entry, these walls could be reduced in length and size and have a significant savings in project cost.

### 1.2. Recommendations

In proceeding with this design process, it is recommended that Feature Design Memorandum Reports be prepared concurrently with physical modeling for the major features of work before proceeding into the design-for-construction and preparation of the construction plans and specifications. This report would provide a final evaluation of the options available for the specific site conditions, select the most appropriate features, optimize the design, and establish the design parameters. Using this document, final construction plans and specifications would be prepared. While the concept level design report presents the design for various features for the specific site, it does not optimize the design nor consider possible ongoing changes. Changes could include the method of handling the ships that would change the dimensions of the locks and reduce wall loads by eliminating the loads transmitted to the walls with the use of locomotives. Selection of emergency closure systems should be considered with development of any project specific security considerations. Also, decisions need to be made on the methods of maintaining the locks and gates, and these decisions could change certain presented details and/or designs of the features. A life cycle economic cost analysis should be performed to assess viability of purchasing a high capacity gate lifter crane to serve in emergency response scenarios and support other canal system maintenance activities. The use of a single lock gate at the Gatun Entrance should be re-evaluated in conjunction with an emergency closure system as a potential cost savings measure.

A Bottom Interlaced Lateral filling and emptying system should be investigated for additional cost saving measures. A cursory investigation indicates that the excavation and founding elevation of lock walls could be raised 4 m compared with the In-Chamber Longitudinal Culvert filling and emptying system design. This design would likely reduce concrete and excavation requirements. The characteristics of a bottom interlaced lateral filling and emptying system are preferred when compared to an in-chamber longitudinal culvert filling and emptying system.