New Locks Alignment at the Pacific Side

Alignment PMD

CHAPTER 1

BACKGROUND

Several alignments have been proposed for the construction of a new lane of locks at the Pacific side of the Panama Canal. In August, 1999, Harza Engineering evaluated some alignments proposed by the Panama Canal Commission and conducted a preliminary screening, from which two alignments were recommended for further study. Alignments were selected using technical, operational, constructibility, economic, and environmental criteria. In May 2003, Consorcio Post-Panamax (CPP) presented design possibilities for constructing a 1-, 2-, or 3-lift lock within the new alignment corridor (alignment P1) recommended by Harza and PCC on the West side of the existing Pacific locks.

Technical criteria included stability of slopes, potential for future expansion, and susceptibility to catastrophic failures. Operational criteria included navigational safety and ship maneuverability; integration with existing operations; and accessibility of equipment, materials, and personnel. Constructability criteria assessed the impact on existing operations; accessibility of construction equipment, materials, and personnel; and ease of construction. Economic criteria involved the cost of the new locks, excavation costs, and construction time. Other criteria also considered included environmental, socio-economic, and relocation issues.

The ACP Canal Capacity Projects Office (IPC) compiled all the studies conducted for the expansion of the canal since 1939, when excavations for larger locks were initiated on the Atlantic and Pacific sides following the existing navigational channels and bypassing the existing Miraflores locks and lake. IPC also reviewed several alternatives investigated during the period after WWII; the alternatives proposed by the governments of the United States, Japan, and Panama as part of the Canal Alternatives Studies Committee (CAS); and studies performed in house by IPC, which again recommended the construction of a lock canal.

These studies were presented to HARZA Engineering in 1999, to CPP as reference for their work on the Pacific side, and to USACE, for their work on the Atlantic side, in January of 2002. This chapter will review the Pacific side alternatives only.

HARZA Engineering recommended alignments P1 and P2 as the best alternatives proposed by the ACP. Alignment P2 was considered as a second alternative because it required the construction of a $281-million barrier dam between Miraflores Lake [at mean water surface elevation of 16m +/- Precise Level Datum (PLD)] and the new navigational channel (at water surface elevation of 26m +/- PLD). Another important navigational parameter not considered by Harza for Alignment P2 was the intersection at the new channel with the existing Gaillard Cut. At that intersection, a northbound ship would have to make an 18º portside turn, and less than 410m later, another starboard turn of 12º.

The terms of Reference for the contract awarded to CPP for the optimization of alignment P1 specified the construction of a 1-, 2- and 3-lift lock with Water Saving Basins (WSB).

In January 2003, CPP recommended to hold the P1A alternative because of navigational considerations. They performed nautical analyses of different maneuvers by a container ship or bulk carrier 386m long, 55m wide and a 15.2m draught for alignment alternatives P1A and P1B.

CPP performed a fast-time simulation at the Waterboukundig Laboratorium in Antwerpen, Belgium validated with data from the towing tank for maneuvers in shallow waters from a coop program between Flanders Hydraulics and Ghent University of Belgium. Some of the parameters considered by CPP were: lay-out of the channel alignment, water depth, bank suction, currents, wind, stopping lengths, sailing directions, and tides. They also considered PIANC's preliminary design rules.

CHAPTER 2

GENERAL INFORMATION

In January, 2003 Mr. Gilberto Moncayo, an experienced Panamanian civil engineer and member of the ACP-SPIA-CAPAC Technical Committee proposed an alignment to the East of P1 alignment, introducing a 9° angle turn between the lock and the intersection with the existing Gaillard Cut. The ACP implemented the guidelines of PIANC's "Approach Channels, A guide for Design", Supplement No. 95 of June, 1997 to consider the preliminary geometry of the navigational channel, location of a triple-lift lock with WSB and intersections of the channels upstream and downstream with the existing navigational channels.

Among the parameters considered were: avoiding bends close to the lock entrances, geology, topography, intersections with existing and future channels, currents, wind, distances to channel edges, cargo, depth, and channel bottom materials. The channel bottom width was established with regard to the design vessel beam (B). Following are the parameters considered from the PIANC's guide for design:

1. Basic Maneuvering……..1.3B
2. Vessel speed: Moderate (8 to 12 knots)…….…..0.1B
3. Prevailing Cross Wind (Knots): Low…….…..0.2B
4. Prevailing cross current (Knots): Low…….0.5B
5. Prevailing Longitudinal current (Knots):…….0.1B
6. Wave height and length:……..….0.0B
7. Aids to Navigation……....0.1B
8. Bottom surface……0.2B
9. Depth of waterway……..0.1B
10. Cargo Hazard level…….1.0B
11. Additional width for bank clearance……..0.5B

Σ=4.1B ⇨4.1*55meters = 225.5m

The initial two alignments considered PMD1 and PMD2 were studied for a bottom channel width of 220m and a bottom elevation of 5.3m PLD. The latest alignment (PMD3) has a channel bottom width of 225m with a 500m transition between the lock bottom elevation of +5.3m PLD and the navigational channel bottom of +7.77m PLD – the final channel elevation once the ongoing Gaillard Cut deepening project is completed. A similar 500m long transition was considered at sea side from –20.62m to –19.70m that is the projected bottom elevation of the Pacific side entrance.

Additionally, the ACP also considered that shifting the alignment to the East would avoid some of the harder rock (basalt) and move into the softer rock (Pedro Miguel and Cucaracha formations) while keeping the lock within basalt formation foundation. The main achievement of this alignment is that it avoids the relatively high terrain to reduce the amount of excavation.

The design vessel considered was the same used by CPP and the width of the transitions was 260m at the bottom of the channel with a bend radius of 2800m. Navigating from the north, vessels would turn 2º 35"to starboard at the Gaillard Cut intersection (they had to turn 11º starboard for alignment P1 and 18º for alignment P2), and then, at the intermediate turn, they would have to turn starboard again 10º 7". At the Pacific entrance intersection in "Balboa Reach," the starboard turn is 18º (it was 22º for alignment P1 and 13º for alignment P2). The intermediate turn of 9º required widening to 260m between tangents and moving the excavation away from Pedro Miguel Dam.

When comparing the different alignments, it is very important to check whether the design parameters are the same. A slight variation of the bottom width or bottom elevation of the channel would represent a significant difference in the amount of excavation. Even within the same alignment, depending on the stationing and transverse template used, the precision or tolerance implemented in the calculation could yield different results. Following is a table comparing different alignments and base parameters.

ALIGNMENT	**LENGTH (Km + m)**	**WIDTH (m)** OF LOCK & ACCESS CHANNEL BOTTOM	NUMBER OF LIFTS	**Volume** EXCAVATION **W/O WSB's** (m^3)
P1 (Harza)	9 + 260	49 & 276	3	**70**
P2 (Harza) (*)	9 + 453	49 & 276	3	**37**
PMD1	9 + 800	61 & 220 (*)	3	**41.31**

(Moncayo)				
PMD2 (Moncayo)	9 + 560	61 & 220 (**)	3	**48.9**
PMD3 (Moncayo)	9 + 630	61 & 225 (**)	3	**66**
P1A (CPP)	10 + 300	61 & 220	3	**77.3**
P1B (CPP)	10 + 100	61 & 220	3	**62.3**
P1C (CPP)	10 + 500	61 & 220	1	**74.25**
P1D (CPP)	10 + 500	61 & 220	1	**76.27**
PDPTE 220	8 + 960	61 & 220 (***)	2 + 1	**41.10**
PDPTE 260	8 + 960	61 & 260 (***)	2 + 1	**46.10**

* Volumes for the construction of a barrier dam at Miraflores Lake are not included.
** Dike at the Edge of Miraflores Lake (Vol.=1,340,000 m^3). This dike could be built with local materials.
*** One 2-lift lock at Miraflores and one 1-lift lock at Pedro Miguel.

Alignments P1 and P2 are documented in Work Order No.1, Evaluation of Lock Alignments, by Harza Engineering and Tams Consultants, Inc. dated August 2000. The first alignment studied in February 2003 was PMD1. This alignment considered using some of the 1939 excavation with the east bank (northbound navigation) entering Miraflores Lake. This alignment yields 41.3M m^3 with a channel bottom elevation and width of +5.63 PLD and 220m, respectively. Due to the amount of work required at the lake, a second alignment was considered West of the lake. With the same parameters, alignment PMD2 yields 49M m^3. Alignment PMD3 yields 66M m^3 with a bottom width of 225m, a bottom elevation of +7.77m PLD with a smooth transition of 500m long to the bottom of the lock at +5.63m PLD. All of the alignments considered seaside bottom elevation at–20.6m PLD.

Alignments P1A through P1D are explained in CPP's final report. Alignment PDPTE (Pacific Dual Parallel To Existing) was described in the "Panama Canal Pacific side Lock Alignments Study" Report prepared in March 2003 by IPC.

Lock dimensions and bottom elevations considered are the same as proposed by CPP. Figures 1 and 2, below, show these alternatives:

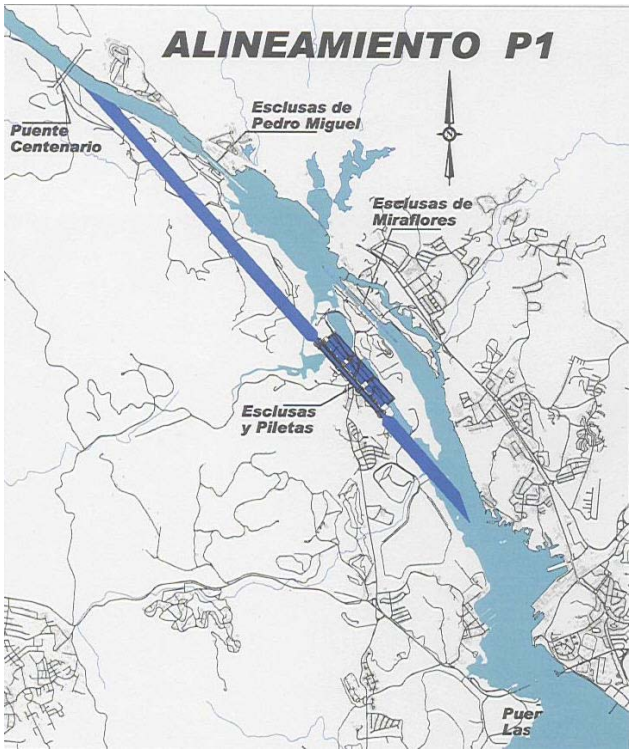

Figure 1: P1 Alignment

Alignment P1 is a straight line between
Intersections at Balboa Reach and Gaillard Cut

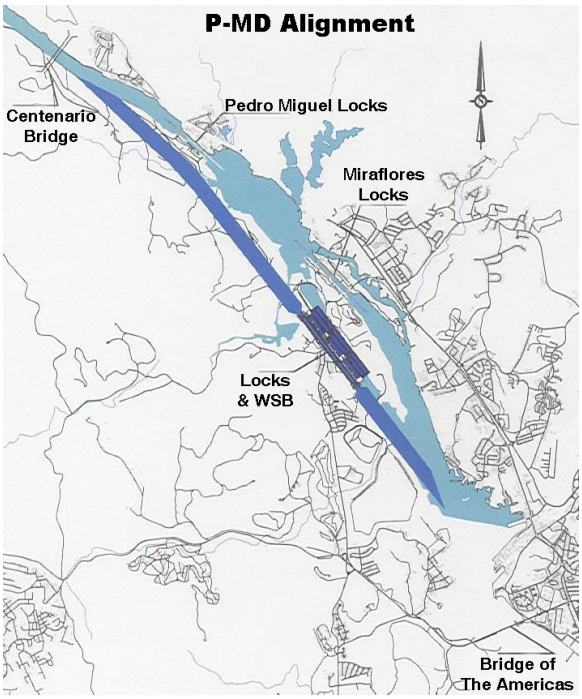

Figure 2. Pacific Locks Alignment PMD3 shown, Alignments PMD1 and PMD2 had the northern approach channel shifted to the East.

Lock alignment alternatives that include shallower channels do not take into consideration that the new Post-Panamax lock does not have access redundancy and that deepening the access channel in the future could be a difficult task if that single, one-way channel is in operation. Furthermore, operations to deepen the channel would be more expensive than excavating the channel at the final elevation in-the-dry. A possibility could be to design a blasting pattern that could be removed or dredged in the future for initial investment savings.

Alignment PMD3 also considered the installation of aids to navigation at the North end of Cerro Nitro and on the East bank at the South end of Balboa Reach. The intermediate 10º bend close to existing Pedro Miguel Locks will need some aids to navigation located at the "island" between the existing lock and the new channel. Four towers per straight segment are required for one-way north and southbound navigation, in addition to the aids to navigation entering the locks. At the south end, targets will also be installed in an area owned by Panama Ports, at the tank farm and East approach to the Bridge of the Americas (owned by MOP). All other aids to navigation will be installed within ACP property.

At the North end, the geometry of the straightened and widened Gaillard Cut was also considered given the fact that the Cartagena PI (coordinates 650424.407,998080.705) South of the new bridge over the Canal would vary due to these future modifications. The aids to navigation for a southbound sailing transit would have to be installed close to the Balboa Dock 16, close to Sosa Hill at the tank farm and/or close to the eastern approach viaduct to the Bridge of the Americas.

Bank transverse slopes included the existing geological information and the geometry of the bends and intersections considered a width of 260m and a radius between tangents of 2800m. The width considered for the excavation at the lock site was 100m, while the excavation and/or fill for the WSB was not considered.

Alignment PMD3 also considered bypassing the UneXploded Ordinance (UXO) area Northwest of the access channel. This alignment aimed to get a minimum excavation and softer rock removal, considering that this would result in lower prices and a shorter execution time.

There are two low terrain areas at the confluences of Río Cocoli and Río Grande at the western edge of Miraflores Lake. To excavate the channel to a bottom elevation of +5.63m or even +7.60m, it would be necessary to build a dike to separate the water of the lake at elevation +16.5m+/- from the water of the new channel at elevation 26m+/-. ACP calculated the required works for this dike, having a crest width of 20m at elevation +30.5m (this elevation includes the potential higher elevation of Gatún Lake), slopes of 1:2 and an impervious core. It could also allow to have gentler slopes and concrete lining on the side of the navigational channel and rip-rap protection on the Miraflores Lake side.

A minimum of 1.34M m^3 would be required to build these dikes. They could be built using 100% local materials taken from the new channel excavation and, with the exception of foundation preparation, all of the work could be performed in-the-dry. If a concrete impervious screen is chosen, it could also help to prevent erosion caused by ship and towboat propellers.

With the available data regarding the geology of the site the ACP estimates there are some 12M m^3 of basalt in the segment of the channel from Kilometer 5+550 to 7+350 of the alignment PMD3 that could be processed and used as fine and coarse aggregate to build locks and WSB at the Pacific and Atlantic sides. The ACP has to perform mechanical and chemical studies of the 40 MPa+/- basalt and verify whether it is suitable for use as coarse and fine concrete aggregate.