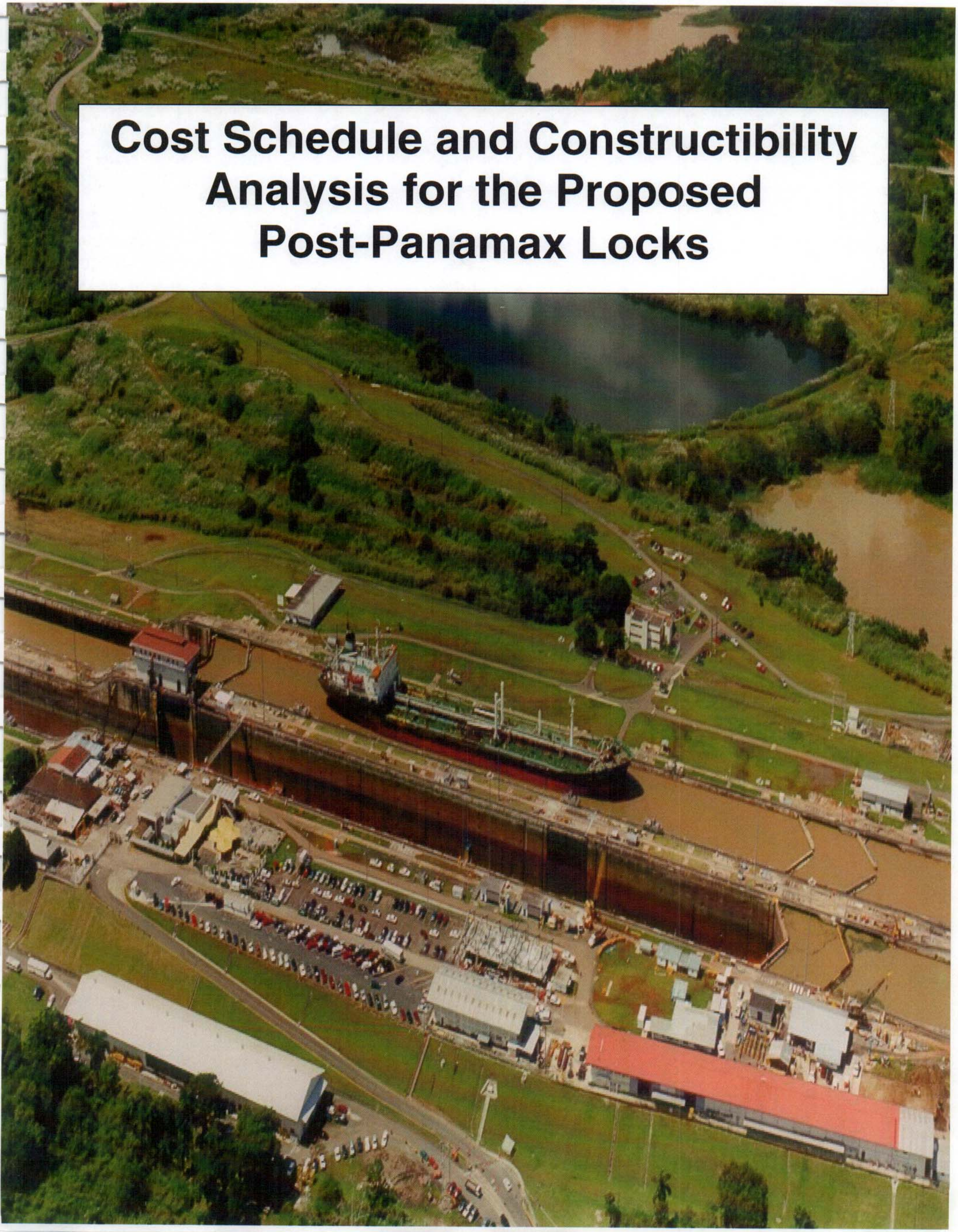
Cost Schedule and Constructibility Analysis for the Proposed Post-Panamax Locks



Executive Summary

1 General

The ACP Locks Cost Estimating Team (Cost Team) was organized with the purpose of studying the constructibility and determining the cost of the concept level designs for the new Pacific and Atlantic locks. With the assistance of consultants from Parsons Brinkerhoff and Montgomery Watson Harza (PB/MWH), the cost team established a cost breakdown structure, calculated the quantities based on the cost breakdown structure, evaluated the methods and equipment required for constructing the Atlantic and Pacific locks as well as the Pacific access channel, and established the schedule for completing the project within a reasonable timeframe.

The scope of the projects studied by the Cost Team was as follows:

> Pacific side. Two contracts would be issued: one for the construction of a three-lift lock with three water saving basins per lift, and another for the excavation and construction of the 5 km long access channel between the new lock and Gaillard Cut. The lock design consists of rolling gates and reinforced concrete walls.
>
> Atlantic side. One contract would be issued for the construction of a three-lift lock with two water saving basins per lift. The lock design consists of miter gates and gravity concrete walls.

As part of the PB/MWH contract, the cost team organized visits to the proposed Atlantic and Pacific lock sites, Puente Centenario and accesses, Gatun Locks, Mt. Hope Industrial Area, Dredging Division blasting operations, and the La Pita excavation site. It also coordinated a visit to the east access to the Puente Centenario. The cost team also received information and technical briefings on cost estimating and scheduling from experts from PB/MWH.

The first step in the cost estimating and scheduling effort was to establish the assumptions under which the estimate would be made. The most important of these assumptions are:

- The cost estimates and schedules are based on the Design-Bid-Build concept but do not include the design period, except for the case of the gates and valves.
- There would be at least four major contracts:
    - Pacific Locks construction
    - Pacific access channel excavation
    - Atlantic Locks construction

  - Design, fabrication, and transportation of gates and valves
- The aggregate and crushed stone required for both sites would be obtained from the excavation of the Pacific locks and access channel.
- There would be enough skilled labor available in Panama to satisfy project construction needs. The contractor's key personnel and specialized labor not available in Panama would be the only foreign personnel participating in the project.
- Price levels are as of March 2004. No escalation factor was applied.

1.1 Pacific Site

A construction project of this magnitude would require facilities for the contractor's offices, shops, warehouses, and other operating infrastructure. To accommodate these facilities on the Pacific site, the ACP would need to acquire 23.2 hectares of land in Cocoli, including 89 existing buildings that are presently under concession to ESPANAM Iberoamerica, S.A. Although the ACP may not need to pay the concessionary for this land, this study assumes that the land would be purchased.

The estimate for the Pacific locks was based on the Three-Lift Concept Level Study with three water saving basins per lift designed by the Consorcio Post Panamax (CPP), as well as other items identified as necessary for the successful execution of the project, such as the diversion of the Cocoli River, the construction of cofferdams at Miraflores Lake and the Cocoli River, reinforcement of the northwest saddle dam at the existing Pedro Miguel Locks, the construction of a saddle dam southwest of Pedro Miguel Locks, relocation of utilities, overhead and fees, and contingencies.

About 2.7 km of the ACP's existing 0.4-m ø potable water lines and 3.2km of IDAAN's existing 0.6-m ø potable water line would be temporarily relocated. Approximately 3.0km of the ACP's existing 12-KV circuits, the telecommunications circuit, and the 44-KV circuit (Line 418) would be temporarily relocated. The permanent relocation of the water, electrical and communication lines would be carried out when the utility crossings for the new locks are completed.

To facilitate drainage and dewatering, the excavation of the lock chambers and lockheads would start from the south (Pacific) end and progress northward until reaching the northern corner of the Gatun approach wall. When the north (Gatun) approach wall is completed, the excavation for the Pacific approach wall would be done. The total time estimated for excavation at the locks is 39 months at a direct cost of USD$65,559,244.

It is assumed that local contractors would do the excavation for the approach channel north of the locks. The excavation would begin just north of the locks excavation and proceed until intersecting the existing channel. Material from the excavation would be used to reinforce the northwest and southwest saddle dams at Pedro Miguel Locks. The total time estimated for excavation of the access channel (including contractors' mobilization) is 72 months at a direct cost of USD$259,466,190.

Concrete work would begin in the lower chamber when the excavation has progressed to about half the length of the middle chamber. Reinforced concrete would be used to build the lockheads, water saving basin conduits and the section of the lock walls that includes the culverts. When the section of the lock wall that includes the culverts is completed, roller compacted concrete and a reinforced concrete facing would be placed on top of it. The backfill behind the wall would be placed at the same time as the roller compacted concrete. The estimated time for the concrete work is 45 months and the estimated direct cost is USD$439, 033,734.

The cost estimate and schedule assume that the gates, valves, and bulkheads would be designed, fabricated and transported to the site under a separate contract. The electromechanical installation work could begin when the civil work in a given chamber is completed. The installation time for the main culvert valves varies between 14 months for the upper valves and 29 months for the lower valves. The installation time for the water saving basin valves varies between 8 months for the upper chamber and 27 months for the lower chamber. All concrete work must be completed and the valves (main culvert and water saving basins) must be in place before the lock gates can be installed. The estimated direct cost of the electro-mechanical work is USD$293,664,520.

Mobilization, demobilization, all foreign labor (assumed to be at supervisory level), contractor's local and foreign offices, maintenance and support facilities and equipment, taxes, tariffs, duties, port charges, contractor fees, bonds and insurances are included in the overhead. The total estimate of mobilization, overhead and fees for the locks is USD$319,911,851. The total estimate of mobilization, overhead and fees for the channel is USD$122,138,940.

The duration of the Pacific locks construction is estimated at six years at a total cost of USD$1,351,418,855. See figure E-1. The cost includes the direct cost, overhead and fees, and the contingencies. The estimated owner's cost for the locks project is USD$145,373,446.

The duration of the Pacific Access channel excavation is estimated at six years at a total cost of $558,715,221. The cost includes the direct cost, overhead and fees, and the contingencies for the excavation of the access channel north of the locks and the removal of the plug at the north end where the access channel intersects the existing cut. The estimated owner's cost for the channel project is USD$60,729,337. See Table E1 for a summary of Pacific site costs.

The contractors' financing and escalation are not included in the estimated cost: these would be included in the ACP Canal Expansion Financial Model.

Figure E1. Pacific Locks construction schedule

DESCRIPTION		TOTAL ($ 000)	LOCAL ECONOMY ($ 000)	FOREIGN ECONOMIES ($ 000)
CIVIL WORK - LOCKS		854,611	378,022	476,588
MECHANICAL - ELECTRICAL - ARCHITECTURAL		296,137	35,277	260,861
TOTAL - LOCKS		**1,150,748**	**413,299**	**737,449**
CIVIL WORK - ACCESS CHANNEL		428,108	163,396	264,712
DREDGING WORK (SUBCONTRACTED)		45,525	17,278	28,247
TOTAL - ACCESS CHANNEL		**473,633**	**180,674**	**292,959**
TOTAL COST PACIFIC SIDE (EXCL CONTINGENCY)		**1,624,381**	**593,973**	**1,030,408**
CONTINGENCY ALLOWANCE				
CIVIL WORK - LOCKS	20%	170,922	75,604	95,318
MECH/ELECTR/ARCH	10%	29,614	3,528	26,086
TOTAL CONTINGENCY - LOCKS		**200,536**	**79,132**	**121,404**
CIVIL WORK - ACCESS CHANNEL	20%	85,622	32,679	52,942
DREDGING WORK	25%	11,381	4,320	7,062
TOTAL CONTINGENCY - ACC CHANNEL		**97,003**	**36,999**	**60,004**
TOTAL CONTINGENCY ALLOWANCE		**297,539**	**116,131**	**181,408**
TOTAL COST LOCKS (INCL CONT ALLOWANCE)		**1,351,284**	**492,431**	**858,853**
TOTAL COST ACC CHAN (INCL CONT ALLOW)		**570,636**	**217,673**	**352,963**
TOTAL COST (INCL CONTINGENCY ALLOWANCE)		**1,921,920**	**710,104**	**1,211,816**
OWNER's COST				
ADMINISTRATION	1.0%	13,513	8,108	5,405
ENGINEERING	5.0%	67,564	40,539	27,026
CONSTRUCTION MANAGEMENT	4.0%	54,051	16,215	37,836
RIGHT OF WAY	1	232	232	-
ENVIRONMENTAL MITIGATION	1	10,000	10,000	-
Total Owner's Cost - Locks	11%	**145,360**	**75,093**	**70,267**
ADMINISTRATION	1.0%	5,706	5,706	-
ENGINEERING	3.0%	17,119	17,119	-
CONSTRUCTION MANAGEMENT	1.5%	8,560	8,560	-
RIGHT OF WAY	1	-	-	-
ENVIRONMENTAL MITIGATION	1	30,000	30,000	-
Total Owner's Cost - Access Channel	11%	**61,385**	**61,385**	**-**
TOTAL OWNER's COST	11%	**206,745**	**136,478**	**70,267**
TOTAL PACIFIC LOCKS COST		**1,496,644**	**567,524**	**929,119**
TOTAL PACIFIC ACCESS CHANNEL COST		**632,021**	**279,058**	**352,963**
TOTAL PACIFIC SIDE PROJECT COST		**2,128,665**	**846,582**	**1,282,083**

Table E-1

1.2 Atlantic Site

Just as for the Pacific site project, the Atlantic site would require facilities for the contractors' offices, shops, warehouses, and other operating infrastructure. There are some buildings in the Gatun town site that could be used by the contractor, but additional facilities would be required. The estimate assumes the purchase of about 60 hectares in the José Dominador Bazán (Davis) area, given its proximity to the construction site. The purchase of the properties in Davis that are close to the locks (refer to the Atlantic Locks report) would also help to avoid complaints due to noise and construction-related nuisances.

The estimate for the Atlantic Locks was based on the Three-Lift Concept Level Study with two water saving basins per lift designed by the United States Army Corps of Engineers (USACE), as well as items identified as necessary for the successful execution of this project, such as dredging of the navigation channel at the north approach and all costs associated with the transportation of aggregate from the Pacific to the Atlantic site.

No temporary relocation of water lines is required on the Atlantic site. However, about 3km of both of the ACP's existing 44-KV circuits (Lines 403 & 404), as well as the telecommunications circuits must be temporarily relocated around the existing north plug of the 1939's locks excavation site during the civil works construction period. The permanent relocation distance for the 0.3-m Ø potable water line is estimated at approximately 1km. When the civil work is completed, both electric power circuits and the telecommunications circuits must be permanently relocated at the electric utilities cross-under of the new locks.

Excavation would begin at the lower chamber and proceed upstream. After the dry excavation of the upper chamber and the upper approach are done, the lower approach would be excavated. The total time estimated for excavation at the locks is 40 months at a direct cost of USD$64,554,041.

Approximately 80% of the upper approach would be constructed in the wet and founded on 2.44 m Ø drilled shafts. It is assumed that this portion of the work would be subcontracted since it requires special barge-mounted equipment and formwork that would not be utilized for any other task. The duration of this portion of the work is estimated at 18 months at a direct cost of USD$34,575,530 for the installation of the caissons and z piles. The concrete cap wall is included in the approach wall concrete.

Concrete work would begin in the lower chamber when the excavation has advanced to about half the length of the middle chamber and proceed towards the upper chamber. Reinforced concrete would be used for the miter gate monoliths, recesses, lock walls where the water saving basin conduits cross through, water saving basin conduits, water saving basins, and the cap wall of the upper approach wall. The remaining lock walls and the lower approach wall would be made of roller compacted concrete. The estimated duration of the concrete work at the locks is 48 months and the direct cost is USD$412,752,255.

The estimate assumes that the gates, valves, and bulkheads would be designed, fabricated and transported to the site under a separate contract. The electro-mechanical installation work could begin when the civil work is completed in a given chamber. The installation time for the main culvert valves varies between 28 months for the recess no. 3 valves and 6 months for the upper valves. The installation time for the water saving basin valves varies between 14 months for the upper chamber and 30 months for the lower chamber. All concrete work must be completed and the valves (main culvert and water saving basins) must be installed before installing the gates. The estimated direct cost of the electro-mechanical work is USD$269,526,301.

Mobilization, demobilization, all foreign labor (assumed to be at supervisory level), contractors' local and foreign offices, maintenance and support facilities and equipment, taxes, tariffs, duties, port charges, contractor's fees, bonds and insurances are included in the overhead. The total estimate for mobilization, overhead and fees is USD$317,126,990.

The duration of the Atlantic locks construction is estimated at six years at a cost of USD$1,372,460,323. The estimated owner's cost for the locks project is USD$188,394,436. See figure E-2. The cost includes the excavation, concrete, electro-mechanical work, dredging, overhead costs and fees, and contingencies.

The contractors' financing and escalation are not included in the estimated cost; these will be included in the ACP Canal Expansion Financial Model.

DESCRIPTION		TOTAL ($ 000)	LOCAL ECONOMY ($ 000)	FOREIGN ECONOMIES ($ 000)
CIVIL WORK - LOCKS		815,333	430,320	385,013
MECHANICAL - ELECTRICAL - ARCHITECTURAL		274,239	29,635	236,391
TOTAL - LOCKS		**1,089,572**	**459,955**	**621,404**
CIVIL WORK - ACCESS CHANNEL		-	-	-
DREDGING WORK (SUBCONTRACTED)		62,036	27,778	34,258
TOTAL - ACCESS CHANNEL		**62,036**	**27,778**	**34,258**
TOTAL COST ATLANTIC SIDE (EXCL CONTINGENCY		**1,151,607**	**487,733**	**655,662**
CONTINGENCY ALLOWANCE				
CIVIL WORK - LOCKS	20%	163,067	86,064	77,003
MECH/ELECTR/ARCH	10%	27,424	2,964	23,639
TOTAL CONTINGENCY - LOCKS		**190,490**	**89,028**	**100,642**
DREDGING WORK	25%	15,509	6,944	8,565
TOTAL CONTINGENCY - ACC CHANNEL		**15,509**	**6,944**	**8,565**
TOTAL CONTINGENCY ALLOWANCE		**205,999**	**95,972**	**109,206**
TOTAL COST LOCKS (INCL CONT ALLOWANCE)		**1,280,062**	**548,983**	**722,045**
TOTAL COST ACC CHAN (INCL CONT ALLOW)		**77,545**	**34,722**	**42,823**
TOTAL COST (INCL CONTINGENCY ALLOWANCE)		**1,357,607**	**583,705**	**764,868**
OWNER's COST				
ADMINISTRATION	2.0%	27,152	16,291	10,861
ENGINEERING	5.0%	67,880	40,728	27,152
CONSTRUCTION MANAGEMENT	4.0%	54,304	16,291	38,013
RIGHT OF WAY	100.0%	17,424	17,424	-
ENVIRONMENTAL MITIGATION	100.0%	20,000	20,000	-
TOTAL OWNER's COST	13.8%	**186,761**	**110,735**	**76,026**
TOTAL ATLANTIC SIDE PROJECT COST		**1,544,367**	**694,439**	**840,894**

Table E2. Total Cost Atlantic Site

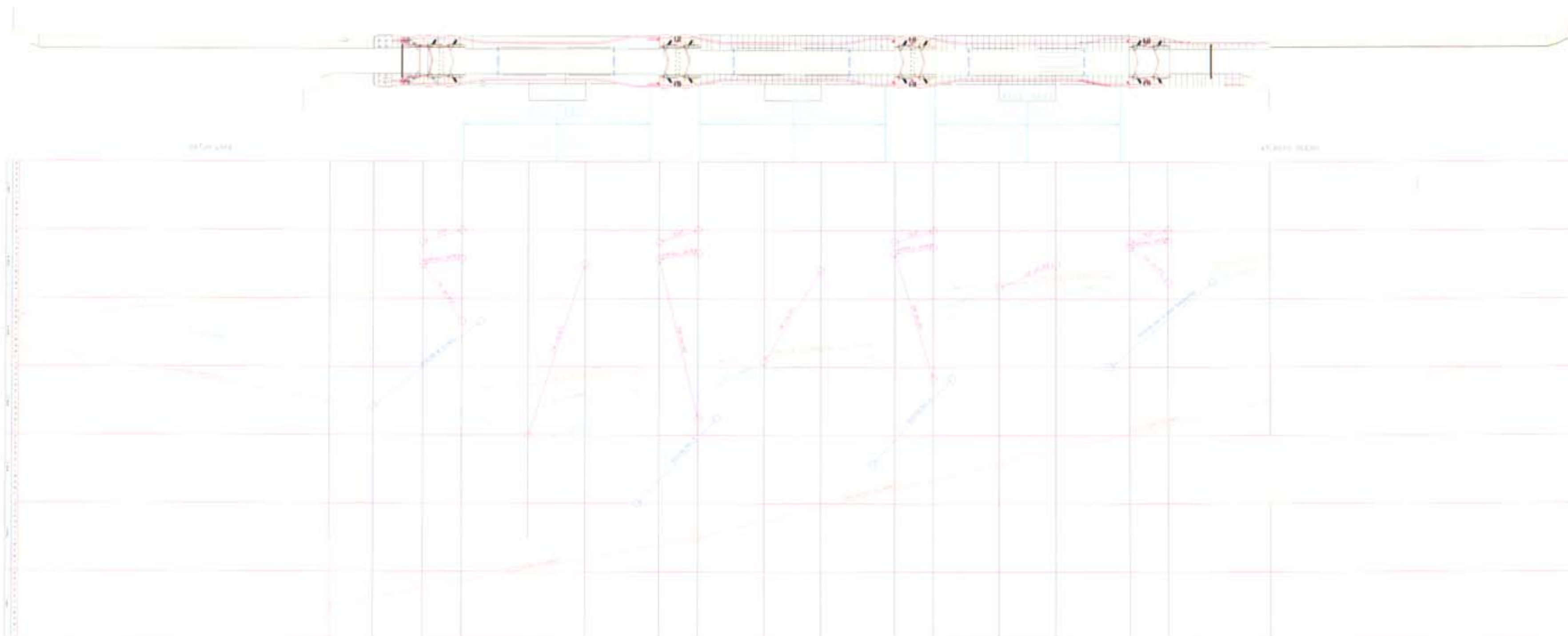


Figure E-2 Atlantic Schedule

2 Background

The Panama Canal Authority (ACP) is conducting a study of the Panama Canal to evaluate the feasibility of constructing facilities and features to provide additional water supply sources and associated hydropower generation; new sets of locks; alternate systems for raising/lowering vessels; making channel improvements and providing supporting features with the purpose of developing a long-range Master Plan to increase the Canal's capacity and capability to transit vessels. The study is designed to meet future traffic demands and customer service needs, and to continue providing efficient and competitive service for the next 25 years and beyond.

Due to the continued increase in transits of Panamax-size vessels, and the existence of Panamax-Plus and Post-Panamax vessels that cannot currently transit the existing canal due to draft and size limitations, studies are underway to determine the maximum size ships and the potential volume of traffic that could be handled by the new locks. As part of this effort, the Canal Capacity Division conducted studies on the possible sizes for the new locks. Of more than a total of 22 alignment options, two alignments were finally selected for the Pacific for the concept level design of Post-Panamax Locks – A2 for the Atlantic and P1. These two alignments would then serve to establish the final location of the post-Panamax locks due to their advantageous navigational, geological and topographic characteristics.

Two contracts were awarded to perform the studies for the design of the new locks – one at the Pacific entrance and the other at the Atlantic. The Terms of Reference (ToR) for both contracts specified a lock size 61m wide by 426.8m long between gates and a minimum depth over the sill of 18.m. The approximate dimension of the gate monolith was given at 30m+/-, the actual length depending on the type of gate selected. Design ships were a 140,000DWT bulk carrier; and a 105,000DWT container ship. The dimensions specified were 54.9m wide by 385.7m long and 15.2m draft.

The first contract, for the design of the Pacific entrance, was awarded to the Consorcio Post Panamax (CPP), a European consortium comprised of the following companies: Tractebel Development Corporation, Technum, Coyne et Bellier, CNR Projects, IMDC, SBE, Port of Antwerp, and FITA. The original contract was for the design of two configurations – three lifts with three water saving basins per lift, and one lift with six water saving basins. The contract was later modified to include two lifts with two water saving basins per lift. The designs were prepared using HARZA's P1 alignment (this alignment was subsequently modified to reduce the volume of excavation and is known as the P1-MD alignment. The total cost of this contract was $1.9 million.

The Atlantic entrance contract was negotiated with the United States Army Corps of Engineers (USACE). The contract was awarded for the design of two configurations: two lifts with two water saving basins per lift, and three lifts with two water saving basins per lift. The two-lift lock was placed in a modified A2 alignment, and the three-lift lock was placed in the A1 alignment because it was too long to fit in the modified A2 alignment. Total cost of the contract was $2.3 million

3 General Assumptions

A number of assumptions were made in the development of the cost estimates and schedules for the Atlantic and Pacific Concept Level Designs for Post-Panamax Locks. Some of them were necessary because the final scope of the project is yet to be determined, while others were intended as contractor decisions over which the ACP has no control. These assumptions are:

- The cost estimates and schedules are based on the Design-Bid-Build concept but do not include the design period, except in the case of the gates and valves.
- Schedule implementation begins at awarding of the contract.
- There would be at least four major contracts.
    - Pacific locks construction
    - Pacific access channel excavation
    - Atlantic locks construction
    - Design, fabrication and transportation of gates and valves
- The aggregate and crushed stone required for both sites would be obtained from the excavation of the Pacific locks and access channel.
- There would be enough skilled labor available in Panama to satisfy project construction needs. The contractor's key personnel and specialized labor not available in Panama would be the only foreign personnel participating in the project.
- There would be no need for construction camps due to the proximity of the cities of Panama and Colon to the construction site.
- The contractor would provide transportation to the site.
- Local labor is included in direct costs; foreign labor, in the overhead.
- Plants, equipment and materials would be imported directly by the contractor due to the large volumes required. However, explosives would be obtained from a local supplier because of the special conditions and permits required for importing this type of materials.

- The gates and valves would be fabricated off the Isthmus and transported to the site for installation by the civil contractor.

- The cost estimate would not include any escalation or contractor's and owner's financing charges. These factors would be included in the ACP Canal Expansion Financial Model.
- The cost estimate would be made using a method that is accepted by the World Bank, the Inter American Development Bank, the Government of China, the Government of the Philippines, and the Government of Argentina, among others. Major work items would be estimated by the analytical method (contractor's method). Minor items (not dependent on a specific project) would be estimated by the unit price method. The unit price would be broken down into labor, equipment and materials. In the US, this information is obtained from RS Means; in Latin America, it is obtained from "Precios de la Industria" (Industry Prices). When Means is used in Latin America, a 2:1 adjustment factor is made (2 man hours to 1 in Means). For this project, the major items are the excavation, concrete work, and manufacturing and installation of the gates.
- Depreciation of the plant and equipment is based on the factory prices. It does not include ocean or inland freight, cargo insurance, interest, port charges, or duties, as these costs are included in the overhead. Price discounts are not considered in the depreciation either.
- Materials and supplies refer to both local and foreign consumables.
- When direct costs are estimated, indirect costs and profit must be added.
- Electric energy and raw and potable water required by the Contractor would be provided by the ACP and billed accordingly.
- All foreign materials, supplies and equipment would be bought in US dollars. No currency risk is considered.
- Price levels are as of March 2004. No escalation factor was applied.

4 Calculation of Direct Cost

• Construction Labor

The current hourly labor wages for the Republic of Panama are those listed in the Collective Bargaining Agreement (Convención Colectiva de Trabajo) of the Panamanian Chamber of Construction – CAPAC (Cámara Panameña de la Construcción) issued on 25 April 2002. Such document sets the minimum hourly wage at US$ 2.22. However, Panama Canal regulations set the minimum wage for personnel working in Canal projects at US$ 2.90. To comply with ACP regulations and to maintain an acceptable salary scale, the salaries from the Collective Bargaining Agreement were taken as reference and adjusted by adding US$ 0.68 (US$ 2.90 - US$ 2.22) to each. The only salary not adjusted in this fashion was that of the guard or watchman, which was adjusted from US$ 1.62 to the minimum of US$ 2.90.

The monthly labor unit rates for foreign personnel proposed by MWH were not changed, but monthly rates for local personnel were adjusted using local rates and hourly salaries from CAPAC as reference.

- **Estimating Procedures**

The estimating procedures were based on the work schedule, crews, and equipment necessary for executing the various tasks within the project completion time.

The work schedule was established by determining the hours per shift, the number of shifts per day, and the number of working days per week. For this project, a six-day workweek with two ten-hour shifts per day was assumed. Sundays, holidays and days lost due to rain were deducted from 365 to obtain the number of working days per year. Then, the average number of working days per month was obtained by dividing the number of working days per year by twelve. Finally, the total number of working hours per month was calculated based on the workweek and the working hours per day. Although the work shift is ten hours, the estimate assumes that personnel do not work all ten hours and the actual effective work hours were obtained by reducing the work availability factor from the total work hours.

Non-working days that must be paid (holidays, vacations, sick leave, death in the family and birth of a child) were calculated and added to working and paid days to obtain the total number of paid days per year. Working and paid days, along with non-working and paid days, were used to calculate labor availability.

Taking all of this into account, and using Collective Bargaining Agreement and Panama Social Security System (Caja de Seguro Social) rates, the social burden factor was computed at 55%.

WORK SCHEDULE FOR SOCIAL BURDEN CALCULATIONS			
Days in Year		**365.00**	days
Sundays		52.00	days
Official Holidays		11.00	days
Days Not Worked		**63.00**	days
Days Worked and Paid		**302.00**	days
Days Paid Not Worked			
Holidays		11.00	days
Vacation		26.08	days
Sick Leave		15.00	days
Death in Family	(3 days/yr x 5%)	0.15	days
Birth	(2 days/yr x 7%)	0.14	days
Total Days Paid & Not Worked		**52.37**	days
Days paid on site but not worked			
Cleanup	(30min/day x Days Worked/10hr/day/60)	15.10	days
Rain Pay	(20 hr/mo x 9 mo / 10 hr)	18.00	days
Total days paid on site but not worked		**33.10**	days
Total Days Paid per Year		**354.37**	days
Factor		**1.17**	

Cash Expenses			
Death in Family	(150$ x 5/100) / (Days Worked x 10 hr)	0.0025	%
Birth	(115$ x 5/100) / (Days Worked x 10 hr)	0.0019	%
Water & Ice	(1.50$/day)/10 hr	0.1500	%
indemnizacion y antiguedad		0.0600	%
bono por asistencia	12 hrs/año - dias por permiso	0.2313	%
programa de asistencia	$120 mes cada 501 trabajadores	0.2395	%
Seguro Social		0.3728	%
Safety Equipment	500$ x 1.00 / Days Worked / 10 hr	0.1656	%
Life Insurance	(2.50$/mo x 12mo)/(Work Days x 10hr)	0.0099	%
Total Cash Expenses		**1.2335**	%
Average Hourly Base Wage		3.8545	%
Total Average Base Wage + Cash		5.0880	%
Factor		**1.3200**	%
Health & Welfare		**1.0000**	%
Total Social Burden		**1.55**	%

A similar procedure was followed for equipment. Reduction factors were applied to the equipment to account for equipment breakdown, efficiency, and other considerations. The work availability factor, plant and equipment (P/E) use time, P/E cycle factor, and the P/E use hourly rate adjustment varied depending on the activity and equipment used. The following table shows a sample chart used for establishing personnel and equipment work availability.

WORK SCHEDULE FOR BASIC PRODUCTION RATES		
Labor Production Rate	**Effective Time**	
Days in Year	365.00	day/yr
Non-working days (sundays, holidays)	63.00	day/yr
Rain Delays	18.00	day/yr
Total Working Days	284.00	day/yr
Average Days	23.7	days/mo
Scheduled Paid	2.00	shifts/day
Scheduled Hours per Shift	10.00	hrs/shift
Scheduled Hours Paid per Month	473	hrs/mo
Work Availability Factor (Caruachi)	0.60	
Effective Hours per Month	284.00	hrs/mo
P/E Use Time (min/eff)	50	min/eff hr
P/E Cicle	0.83	
P/E Use Hourly Rate Adjustment (Excluding Cranes)	0.85	
P/E Use Hourly Rate Adjustment (Cranes)	0.55	
P/E Use Hourly Rate Adjustment (Average)	0.70	

Crews required for the various activities were determined and the man-hours required of the various tasks and the costs associated with them were calculated based on the schedule. The same was done for equipment.

- **Construction Equipment**

Equipment and material costs were taken from quotations provided by local suppliers or from Means Heavy Construction Cost Data 2003.

5 Legislation Regarding Local and Foreign Labor

Hiring of local and foreign labor is regulated by the Panamanian Labor Code (Código de Trabajo de la República de Panamá), which establishes the maximum ratio of foreign to local employees in a company and the terms and conditions to be honored in these situations.

In Article 17, the Panamanian Labor Code states that all employers must maintain a proportion of not less than 90% of Panamanian employees vs. 10% foreigner employees for non-specialized labor. In the case of technical or specialized labor, foreigners cannot exceed 15% of the total number of employees.

A greater proportion of technical and specialized foreign labor would be allowed, however, only for a fixed period of time and must be approved by Panama's Ministry of Labor (Ministerio de Trabajo). This authorization would be issued for a one-year period, with the option for extension for a maximum of 5 years.

Also, Article 20 of Panama's Constitution establishes that Panamanians and foreigners are equal under the Law. However, for issues concerning labor, safety, morality, public security and national economy, certain activities carried out by foreigners in general could be subjected to special conditions.[1]

	Atlantic Locks		**Pacific Locks**		**Pacific Channel**	
Local	1305	95%	1675	96%	1619	100%
Foreign	67	5%	67	4%	--	--
Total	1372	100%	1742	100%	1619	100%

The table above shows the proportion of foreign vs. local employees in compliance with the Panamanian Labor Code

5.1 Legislation Applicable to the Importing of Construction Plant and Equipment

Panama's General Customs Directorate (Dirección General de Aduanas), a section of Panama's Ministry of Economy and Finance (Ministerio de Economía y Finanzas) is currently responsible for administering the Panamanian Customs System. This system has its legal basis in the Panamanian Constitution, international treaties and agreements, decrees, and other applicable legislation.

One of the most relevant of these agreements was signed in July 1997, when Panama officially joined the World Trade Organization (WTO) and pledged to adjust its tariff system to international

[1] Source: Código de Trabajo de la República de Panamá, fourth edition, 1998, Editorial Mizrachi y Pujol S.A.
Constitución Política de la República de Panamá, reformada por los actos reformatorios de 1978, por el acto constitucional de 1983 y los actos legislativos 1 de 1983 y 2 de 1994

Import duties in Panama are calculated on an ad valorem (according to value) basis. The ad valorem system uses the declared CIF (Cost-Insurance-Freight) value for the computation of the tariff.

No import license is required from a company if it already has a commercial license issued by the Ministerio de Comercio e Industria (Panama's Ministry of Commerce and Industry). However, the equipment imported to Panama has to be brought through a customs broker certified by the Panamanian Government.

The basic documentation required for importing equipment is:

- Customs declaration prepared by a customs broker
- Commercial Invoice (either in English or Spanish)
- Airway Bill or Bill of Lading
- Commercial License Number

In order to get a commercial license in Panama, a company must first be established in the country. This takes approximately 15 to 60 days with lawyer fees ranging from USD$600 to USD$1,500. Once the company is established, an application must be filled out and payment of USD$50 made to the Ministry of Commerce and Industry for the issuance of the commercial license for industrial type companies. [2]

6 Calculation of Indirect Costs

6.1 Mobilization and demobilization

Mobilization and demobilization costs were calculated for five main items: mobilization of plant and equipment, installation of plant and equipment, construction of temporary facilities, personnel mobilization, and clean up and demobilization.

[2] Sources: Dirección General de Aduanas, "Manual de Declaración Aduanera", Dirección General de Aduanas Web site, <http://www.aduanas.gob.pa/>, accessed on February 05, 2004.
Dirección General de Comercio Interior, "Requisitos para Licencias Comerciales", Ministerio de Comercio e Industrias Web site, <http://www.mici.gob.pa/sitiosf/html>, accessed on February 26, 2004.
Guía de Inversión de la República de Panamá, Ministerio de Comercio e Industrias, 2001. Printer Colombiana S.A.
Cámara de Comercio Colombia Panamá, "Guía para exportar a Panamá", Cámara de Comercio Colombia Panamá Web site, < http://www.cccolombiapanama.org/docs.hmt>, accessed on February 19, 2004.

Mobilization of the plant and equipment includes the cost of maritime transportation, duties, port charges, land transportation and labor involved in assembling the equipment at the site. The installation of plant and equipment refers to all work at the site required for this purpose. This includes earth movement and construction of foundations for the various plants and shops.

The construction of temporary facilities includes project access, buildings, and utilities. The project access refers to the earthwork, road construction, relocation or rehabilitation necessary to provide access to the site and the office and shop areas. The temporary buildings included in the estimate are the main office, field offices, warehouses, shops, first aid station, mess halls, transfer stations, soils lab and concrete lab. Utilities include on-site and building lightning, telephone system, connection to existing water and electric lines, relocation of utilities in compliance with the project and construction of a sewage treatment plant.

The costs associated with personnel mobilization refer to foreign personnel and include the cost of their transportation as well as their belongings. The cost allows for a 25% turnover in personnel for the duration of the project. This item was not included in channel excavation costs since it was assumed that local contractors would perform this task. Demobilization costs include repatriation of the foreign personnel and their belongings, as well as the disposition of the equipment.

Shipping for the plant and equipment was calculated based on the tonnage listed and then multiplied by the cost per ton of freight and insurance. Panama's General Controller's Office provided the data required to calculate the average freight cost for the last 12 months.

Port charges and the customs broker's fee were assumed to be 1.5% of the total cost of the plant and equipment. The assembly of the plants was calculated based on a crew in which 70% of the labor was local and 30% foreign.

6.2 Maintenance of Temporary Facilities

This item refers to the maintenance cost of the temporary buildings, shops and infrastructure throughout the life of the project. For this purpose, an estimate was made to account for maintenance requirements and crews and equipment were allocated for this activity.

Maintenance of these facilities, including the temporary project access, buildings, general utilities, was calculated based on percentages proposed by MWH, which range between 11% and 17% of the total cost of this infrastructure. These percentages remain unchanged.

6.3 Supervision and Other Indirect Labor

The estimate assumed that all personnel at supervisory level were accounted for in the overhead section. The other indirect labor included in this item was the office staff (e.g. clerks, secretaries, drivers), support staff (e.g. nurses, doctors, accountants), and any labor not directly attributable to one of the paid items.

The cost of administrative and supervisory staff was established based on MWH experience in previous projects of this scale, in order to determine the number of employees not directly related to paid activities. Also, the time in months for all employees was determined based on their specific responsibilities.

The organizational chart is shown in Appendix A.

6.4 Duties, Permits and Port Charges on Construction Plant and Equipment

In the case of construction plants and equipment, tax payments required per customs declaration are as follows:

- **Tariff or import duty.** It is the sum of all duties charged per equipment declared. Table 9.1 below shows the tariffs for the main equipment to be used.

Equipment/Machinery	Tariff Line	Tariff (Ad valorem)
Plant Equipment		
Machinery for concrete mixer plant	8474-3100	3%
Machinery for crushing plant	8474-2000	3%
Screening Plant machinery	8474-1000	3%
Ice-making machinery	8418-6910	3%
Cranes		
Tower Cranes	8426-2000	10%
Crane trucks	8705-1000	5%
Construction Equipment		
Excavators	8429-5210	5%
Front-end shovel loaders	8429-5100	3%
Bulldozer tractors	8429-1100	3%
Road rollers	8429-4000	10%

Haul trucks	8704-1000	10%

Table 9.1. Post Panamax Locks Equipment Tariffs

Note. Panama implemented in 1995 the Harmonized System (HS) as its international trade classification system.

- **ITBMS (Impuesto de Transferencia de Bien Mueble y Servicios).** It is the total amount of transfers and service taxes calculated for each declared equipment. It is 5% over the CIF value plus tariff. ITBM = 5% * (CIF + Tariff)

- **T.A.S.A. (Tasa Administrativa por Servicios Aduaneros).** Each customs declaration pays a fixed tax of USD$73.50 called TASA if its value is higher than USD$2,000.

- **Declaration Fee.** It is USD$2.00 per every 5 items declared.

All of the above taxes could be exempted if the equipment is consigned to the Panama Canal Authority (ACP); however they have been included in the cost of the equipment as a separate item.

For the importing of construction plants and equipment, it is also important to consider other payments required, such as:

- **Customs broker fee.** It is approximately 1%. of the CIF value of the equipment.

- **Port charges.** For the Balboa terminal, port charges for heavy equipment are USD$13.50 per ton if the equipment does not have wheels to roll off the vessel. If the equipment has wheels, the charge is USD$315 per vehicle.

  If the equipment comes in containers, the charge is USD$260 per container movement, regardless of the type of container (TEU, FEU, etc).

  All charges are subject to an additional surcharge of 25% during Panama's national holidays. A cargo storage fee is charged after 7 business days spent at the terminal.

- **Import permits for construction equipment.** Depending on the type of equipment, permits granted by the corresponding authority would be required. The permits required for some of the construction equipment are described in table 9.2 as follows: [3]

Equipment	Authority
Motor Vehicles with fuel as source of energy	Ministry of Health – Hazardous Waste Department
Air Conditioning Equipment (including ice makers)	Ministry of Health – Hazardous Waste Department
Telecommunications Equipment (Radar, Antennas, etc)	Public Services Regulating Entity
Any Vehicle for transportation of goods or people	National Traffic and Land Transportation Authority – Weights and Dimensions

Table 9.2. Equipment that requires special permits

6.5 Equipment Tariffs

To determine an average tariff of import duty fee for the plant and equipment, the entire list was classified in major groups of items with similar tariffs. Then, a weighted average was calculated according to the proportion in dollars for each group as compared to the total amount for plant and equipment.

6.6 Taxes on Permanent Materials and Consumables

The three major materials or consumables identified for this construction project are cement, steel and diesel.

In the case of materials and consumables, tax payments required per customs declaration are as follows:

- **Tariff or import duty.** It is the sum of all duties charged per volume of material declared. Table 9.4 below shows the tariffs for the main materials and consumables to be used.

Sources:
Dirección General de Aduanas, "Manual de Declaración Aduanera", Dirección General de Aduanas Web site, <http://www.aduanas.gob.pa/>, accessed on February 05, 2004.
Free Trade Area of the Americas (FTAA) Database, <http://www.alca-ftaa.org/ NGROUPS/NGMADB_s.asp> accessed on February 26, 2004.

Material/Consumable	Tariff Line	Tariff (Ad valorem)
Cement	2523-2900	10%
Clinker	2523-1000	1%
Steel		
Bars	7214-2010	10%
Pipes	7303-0010	10%
Sheet piling	7301-1000	3%
Flat forms ("platinas")	7212-1020	1%
U, L or H Sections	7216-1000	1%
Diesel	2710-0051	0%

Table 9.4. Import tariffs for the main materials and consumables

Note. Panama implemented in 1995 the Harmonized System (HS) as its international trade classification system.

- **ITBMS (Impuesto de Transferencia de Bien Mueble y Servicios).** It is the total amount of transfers and service taxes calculated for each declared material. It is 5% over the CIF value plus tariff. ITBM = 5% * (CIF + Tariff)

- **T.A.S.A. (Tasa Administrativa por Servicios Aduaneros).** Each customs declaration pays a fixed tax of USD$73.50 called TASA if its value is higher than USD$2,000.

- **Declaration Fee.** It is USD$2.00 per every 5 items declared.

- **Impuesto al Consumo de Combustible y Derivados del Petroleo (ICCDP).** Since 1992, petroleum derivatives are taxed with this duty, which is related to the number of gallons consumed. For diesel, it is USD$0.25 per gallon.

Even though all of the above taxes have been included in the cost of the material, they could be exempted if the material is consigned to the Panama Canal Authority. For the purposes of cost calculation, they have been included as a separate item.

It is also important to consider other payments required for the importing of materials and consumables, such as:

- **Customs broker fee.** It is approximately 1% of the CIF value of the equipment

- **Port charges.** For the Balboa terminal, port charges for dry bulks, such as clinker and cement, are USD$1.25 per ton, while the charge for liquid bulk is USD$0.75 per ton.

  If the material comes in containers, the charge is USD$260 per container movement, regardless of the container type (TEU, FEU, etc).

  All these charges are subject to an additional surcharge of 25% during Panama's national holidays. A cargo storage fee is charged after 7 business days spent at the terminal.

- **Import permits for materials and consumables.** No import permits are required for steel and cement. The permits required for some of the materials or consumables for the construction are described in table 9.5 below. [4]

Material/Consumables	Authority
Any petroleum derivatives imported during the suspension period of ICCDP.	Ministry of Commerce and Industry
Paints, leaded glues	Ministry of Health
Dynamite, detonators, any type of explosives	Ministry of Government and Justice/ Panama Fire Corps

Table 9.5. Materials and consumables that require special permits

6.7 Estimating procedures – Materials

The procedure was similar to the one used for the plant and equipment, however, only four major groups were segregated based on their impact in the total cost. The four major groups were cement, reinforced steel, metal forms and others.

4 Sources:
Dirección General de Aduanas, "Manual de Declaración Aduanera", Dirección General de Aduanas Web site, <http://www.aduanas.gob.pa/>, accessed on February 05, 2004.
Free Trade Area of the Americas (FTAA) Database, <http://www.alca-ftaa.org/ NGROUPS/NGMADB_s.asp> accessed on February 26, 2004.
Cuevas, Fernando, Istmo Centroamericano: Informe sobre abastecimiento de hidrocarburos, 2002, Naciones Unidas - Comisión Económica para América Latina y el Caribe (CEPAL), septiembre 2003, CEPAL México.

7 Other Financial Information

7.1 Legislation Regarding Currency Controls and Exchange

There is a free flow of capital transfers in Panama. In fact, this is one of the main characteristics of the Panamanian banking system, complemented with the use of the U.S. Dollar as legal tender, the absence of a Central Bank and implementation of banking secrecy policies.

7.2 Cost of Performance Securities and Guarantees

ACP acquisition regulations establish the rules for the acquisition and contracting of goods and services for the Panama Canal. Chapter 7 of these regulations refers specifically to guarantees and bonds required for a contract.

Bonds shall be constituted in cash or in bonds issued by insurance companies, sureties, or through bank warranties or certified checks issued on behalf of the ACP.

ACP Acquisition regulations refer to five types of bonds:

- Bid Bonds
- Performance Bonds
- Payment Bonds
- Bonds for advance Payments
- Other Guarantees and insurance

- **Bid Bonds**

Some contracts would require a bid bond to guarantee the firm offers and the formalization of the contract. In these cases, a bid bond accompanying the proposal should not be less than 10% of the proposal value. This bond would normally be valid for 90 days unless otherwise specified.

- **Performance Bonds**

The contract performance bond guarantees compliance with the contract and correction of any pertinent deficiencies after it is completed. Coverage shall not be less than fifty percent (50%) of the contract amount for construction contracts. In the case of the acquisition of goods and services, coverage shall be one hundred percent (100%) of the contract amount.

Source:
Guía de Inversión de la República de Panamá, Ministerio de Comercio e Industrias, 2001.

In the case of movable property, the performance bond shall be effective for the performance period of the main contract plus a period of one year to cover for any hidden defects; except in the case of consumable movable property, in which case the coverage period shall be six (6) months. In the case of construction contracts, the performance bond shall be effective for a period of three (3) years, to cover for defective construction or reconstruction costs of the work or real estate property.

- **Payment Bonds**

The payment bond guarantees payment to third parties for labor services and goods provided during the performance of the main contract. Its amount shall be fifty percent (50%) of the contract amount, when the amount of the contract is less than USD $1,000,000.00; forty percent (40%) when the contract amount is over USD $1,000,000.00 but less than USD $5,000,000.00; and USD $2,500,000.00 when the amount of the contract is over USD $5,000,000.00.

The payment bond shall be effective for the contract performance period plus one hundred and eighty (180) calendar days from the date of the last publication of the notice of completion of the work in a nationwide coverage newspaper, and its satisfactory acceptance by the Panama Canal Authority. Third parties shall file any pending claims against the contractor within this deadline.

A contract winner shall submit a performance bond and a payment bond within ten (10) business days following the formalization of the contract.

- **Bonds for advance payments**

Bonds for advance payments guarantee the reimbursement of a specific amount paid to a contractor in advance for the timely and proper execution of a contract. The penalty amount for this bond shall not be less than ten percent (10%) of the amount paid in advance, and shall have an effective period similar to the contract, plus an additional thirty (30) days. The contractor's responsibility ceases after the amount paid in advance is reimbursed.

The contracting officer shall require the contractor to submit a bond for advance payments within ten (10) business days following the signing of the contract.

- **Other Guarantees and insurance**

According to Article 122 of ACP Acquisition Regulations, when the purpose of the contract involves construction or rendering of services within ACP operating areas, the contracting officer may include contract clauses in the solicitation document to provide coverage for civil liability and damages to third parties. [5]

7.3 Cost of bonds

The charge for a surety bond is referred to as the bond premium. Generally, there is no charge for the bid bond if performance and payment bonds are required. The performance bond premium is typically 0.5% to 2% of the contract amount. In many cases, performance bonds incorporate payment bonds, so no additional premium is charged for those services.

Rates if 1% and 1.75% were used to calculate performance bonds and advance guarantees, respectively. However, note that the advance guarantee is only based on the amount advanced to the contractor.

7.4 Requirements and Cost of Insurance (Builders Risk, OCIP)

The cost of insurance depends on the type of contractor, the length of the contract and the specific conditions of the project.

A "full risk coverage insurance" was estimated based on conversations with the Risk Office and insurance brokers. The fee was established at 0.7% of the total amount of the contract and 0.6% for other insurances such as builders risk coverage.

7.5 Contractor's Fee and Home Office Expense

The estimate includes bidding expenses prior to the awarding of the contract as well as home office expenses that are due to the project. It is usually estimated based on a percentage of the total amount of the contract, which in this case is 2%, to cover for any expenses incurred in by the main office.

5 Source:
Acquisition Regulation of the Panama Canal Authority. Agreement No. 24 of October 4, 1999 modified by agreement 34 of May 30, 2000 and Agreement No. 48 of August 7, 2001.Reglamento de Contrataciones (English version).
Surety Information Office, "The Importance of Surety Bonds in Construction", <http://www.sio.org>, Surety Information Office Web site, accessed on March 10, 2004.

Based on MWH experience, separated markups were established for labor (15%), plant and equipment depreciation (5%), plant and equipment operator (10%), materials and services (7%) and indirect costs (10%). These proposed rates were not changed in the estimate.

7.6 Contingencies

Once direct and indirect costs have been calculated, a thorough evaluation of the project is performed in order to identify gaps and unforeseen events that could affect cost estimated during construction.

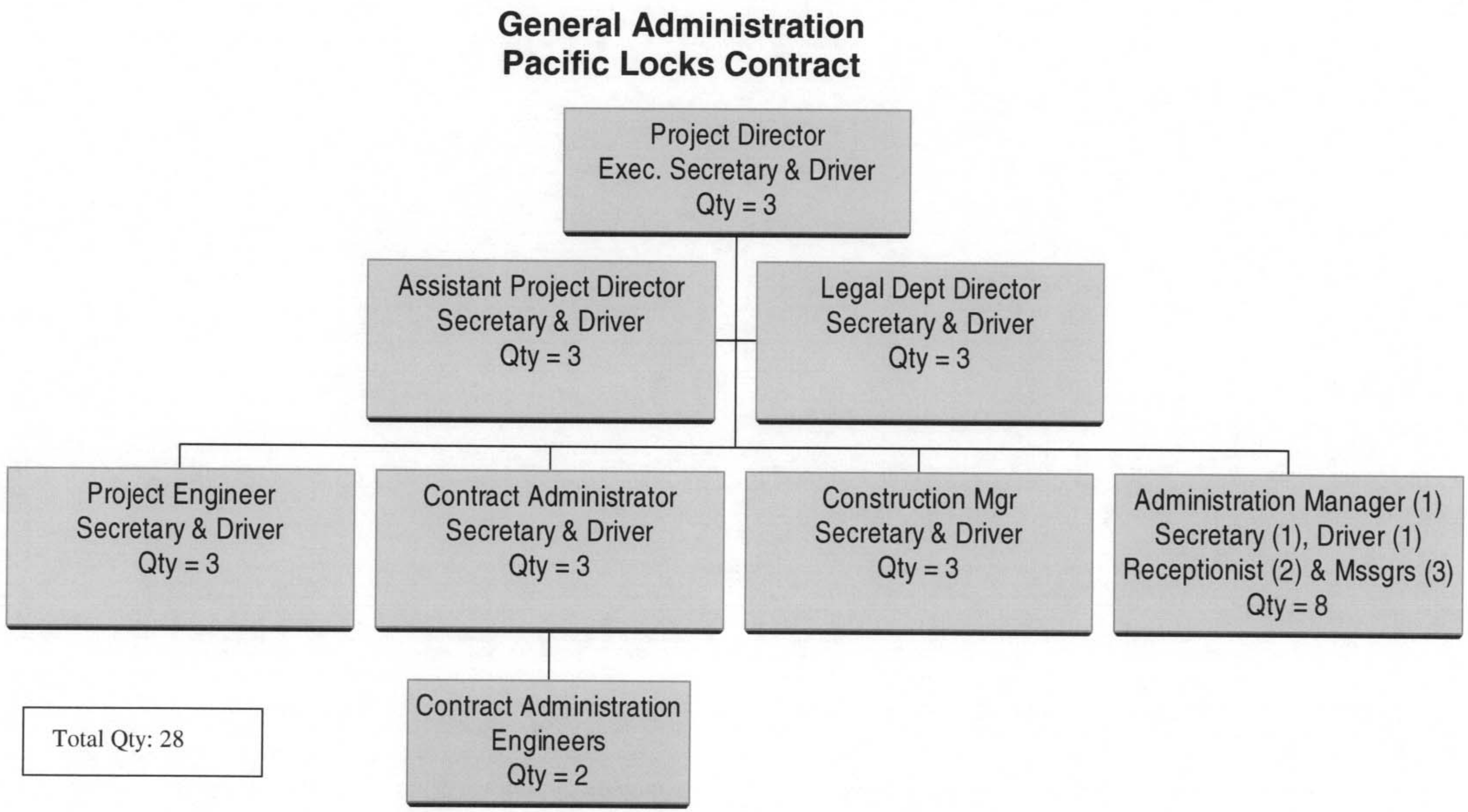
Separate contingencies were established for civil, electro-mechanical and excavation work. This area is unique and is established according to project characteristics and surrounding environment.

7.7 Interest Rates for Construction Plant and Equipment Financing

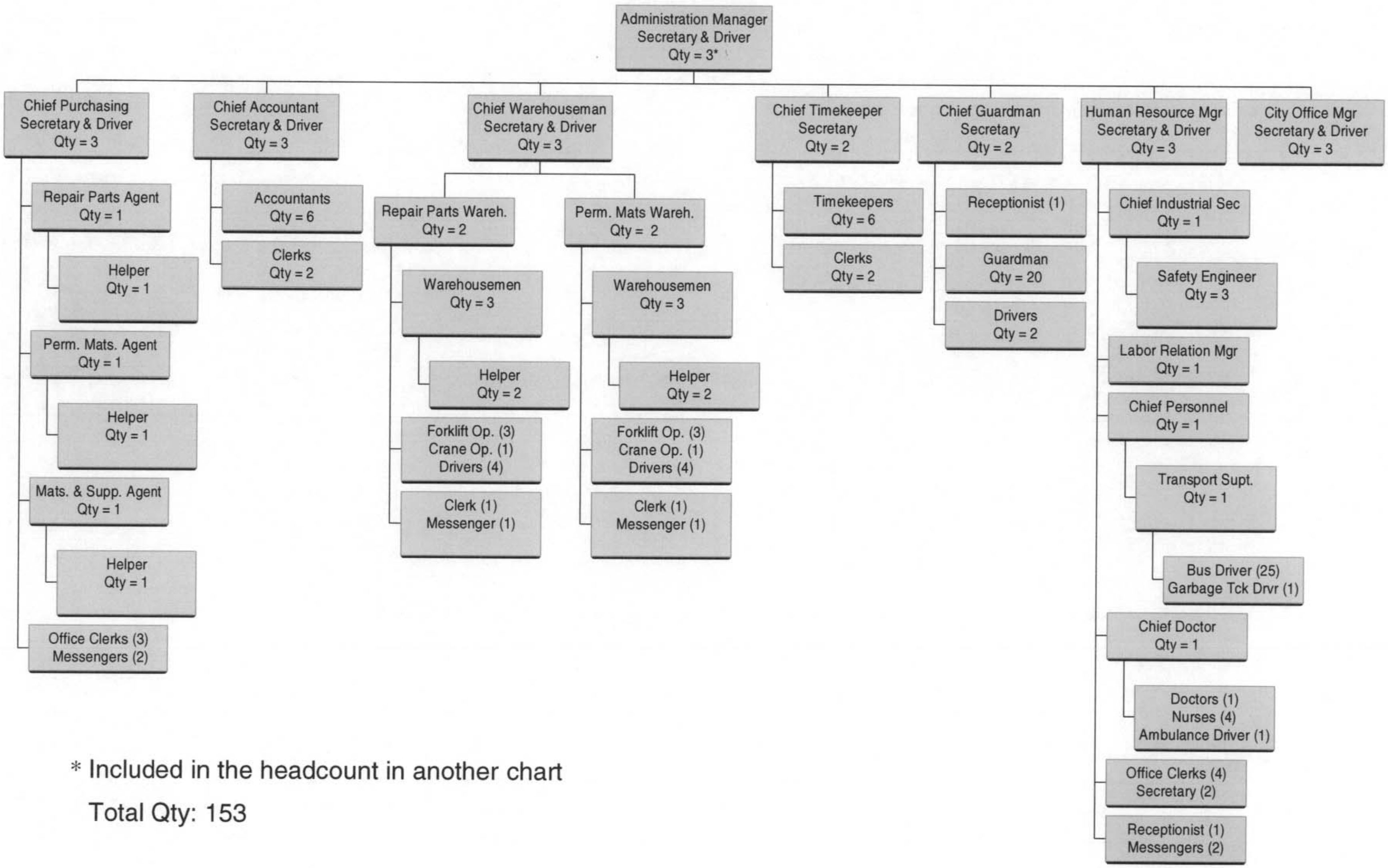
This section has been eliminated from the scope of work. It would be included as part of the ACP Canal Expansion Financial Model.

Appendix A – Organizational Charts

Pacific Side Locks Contract



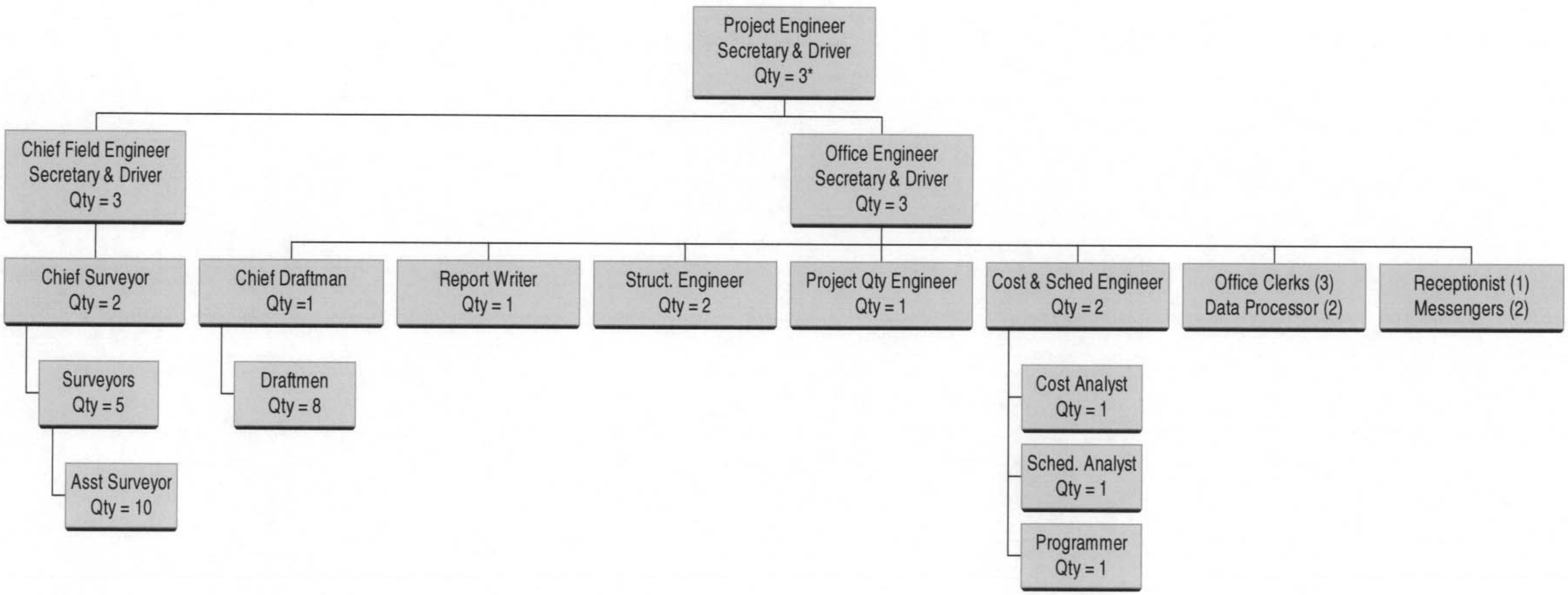
Administration
Pacific Locks Contract



* Included in the headcount in another chart

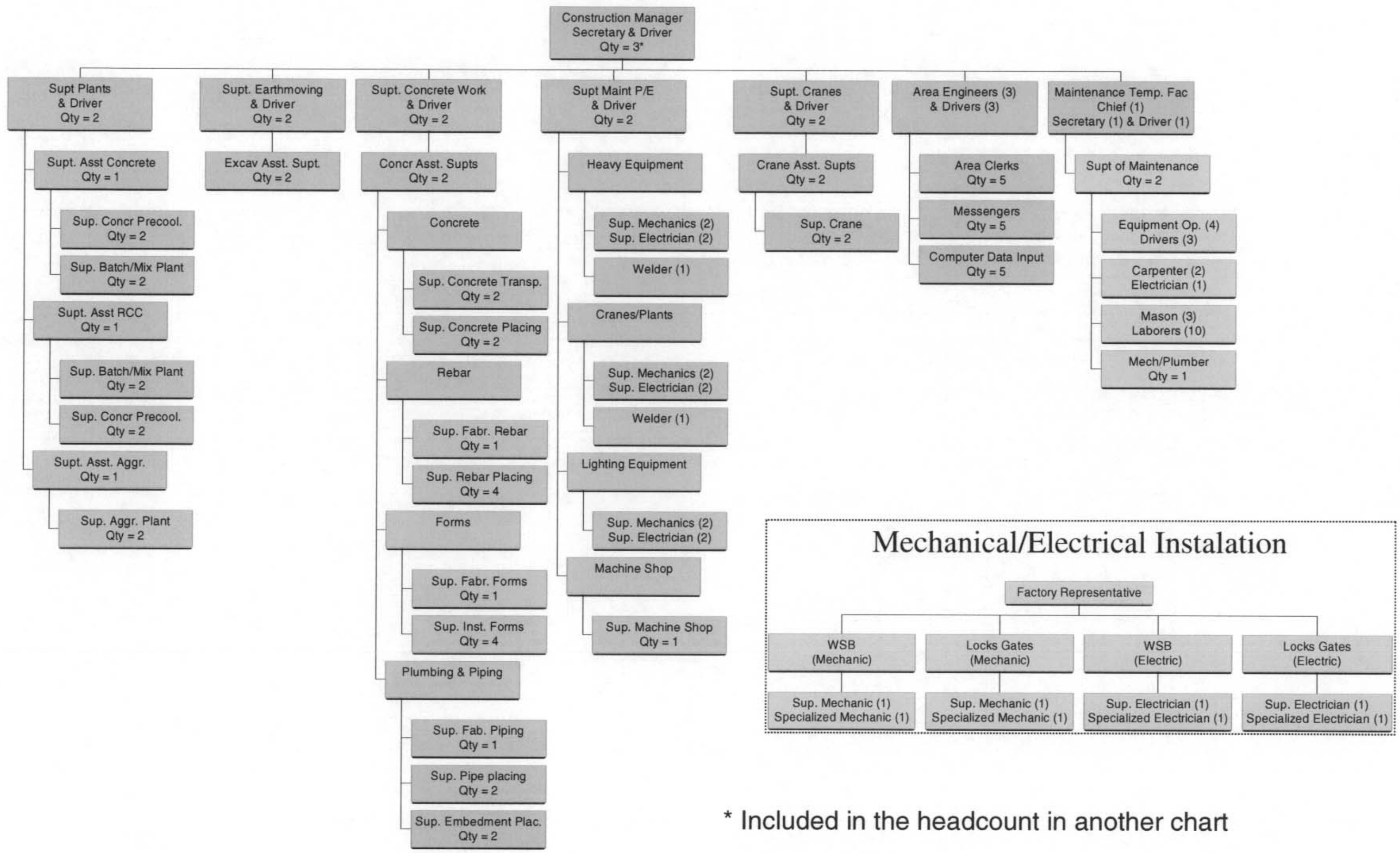
Total Qty: 153

Construction Engineering
Pacific Locks Contract



* Included in the headcount in another chart
Total Qty: 49

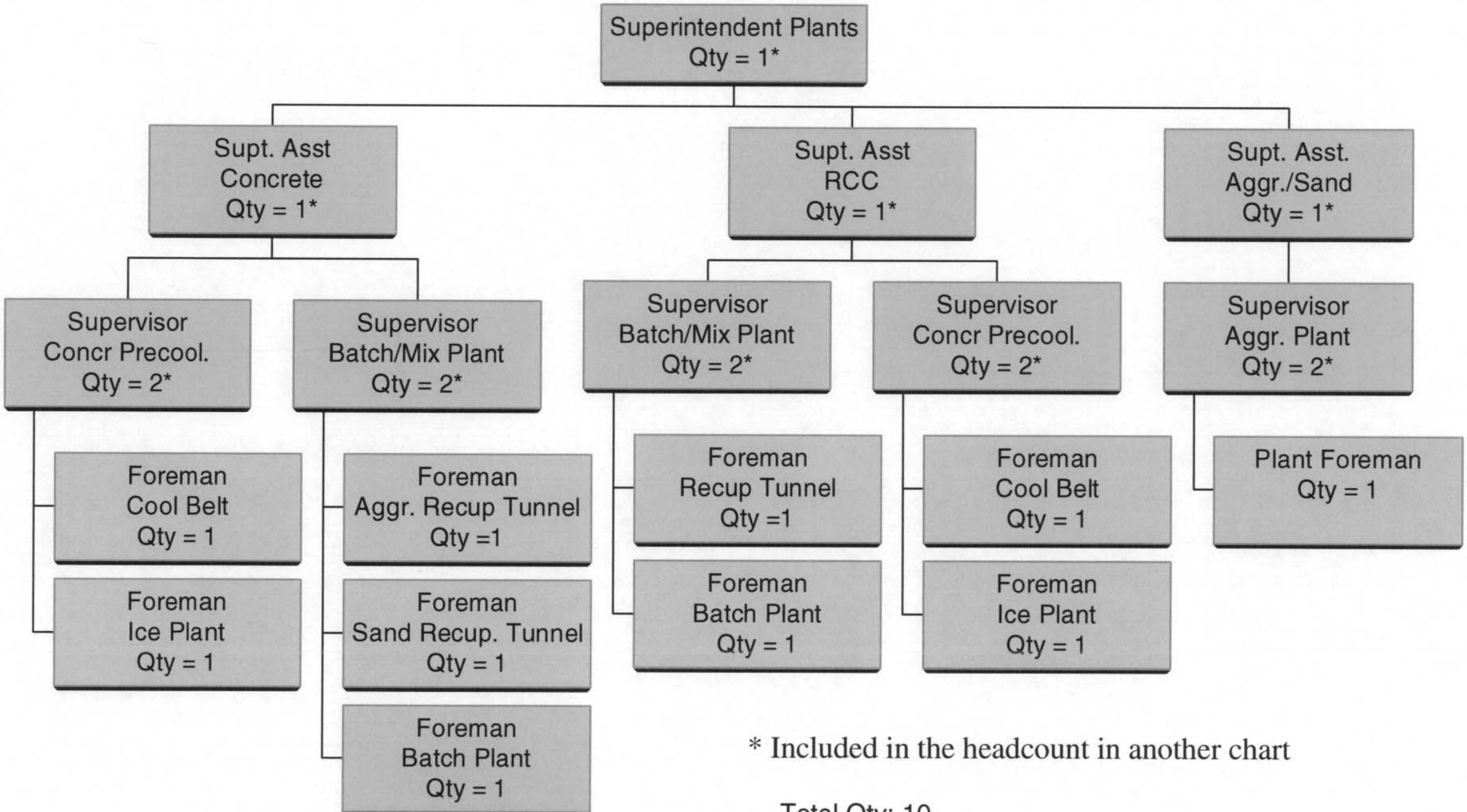
Construction Supervision
Pacific Locks Contract



* Included in the headcount in another chart

Total Qty: 123

Plants
Pacific Locks Contract

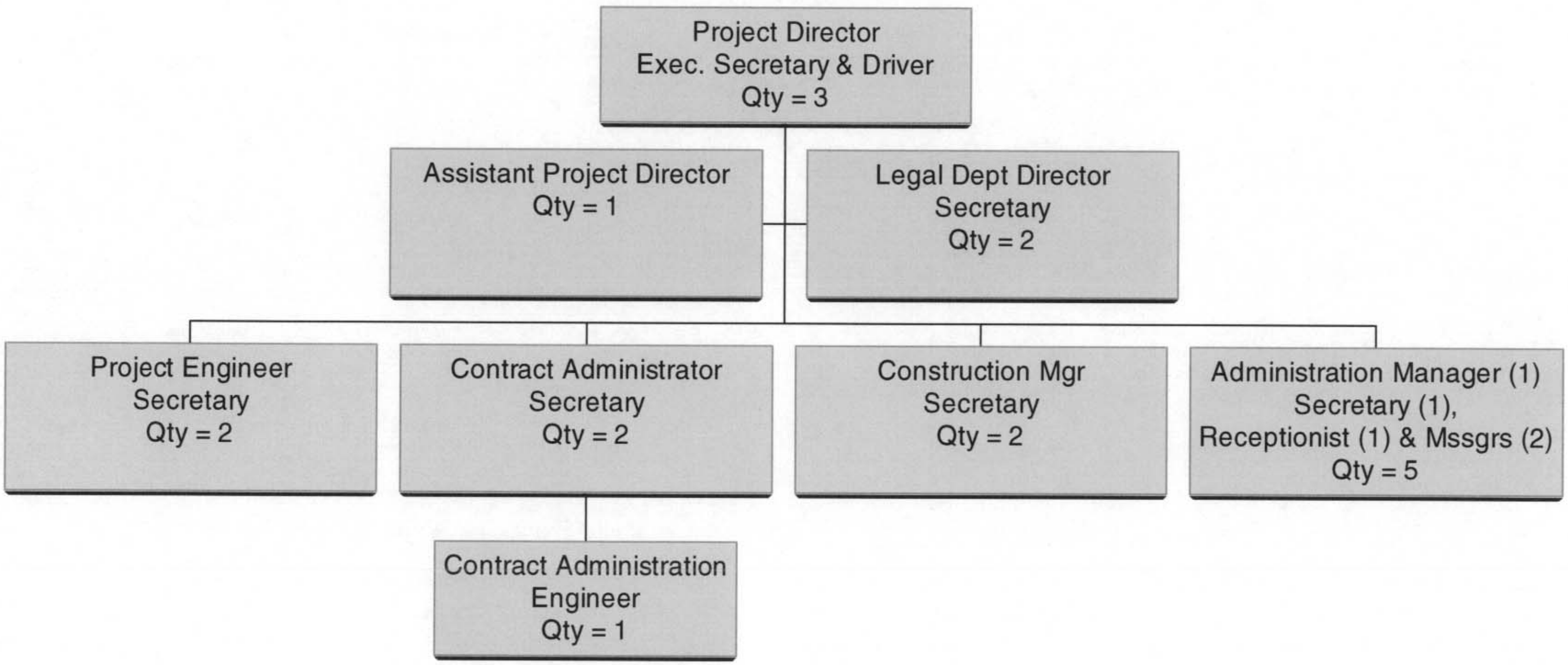


* Included in the headcount in another chart

Total Qty: 10

Pacific Side
Channel Excavation Contract

General Administration
Channel Excavation Contract



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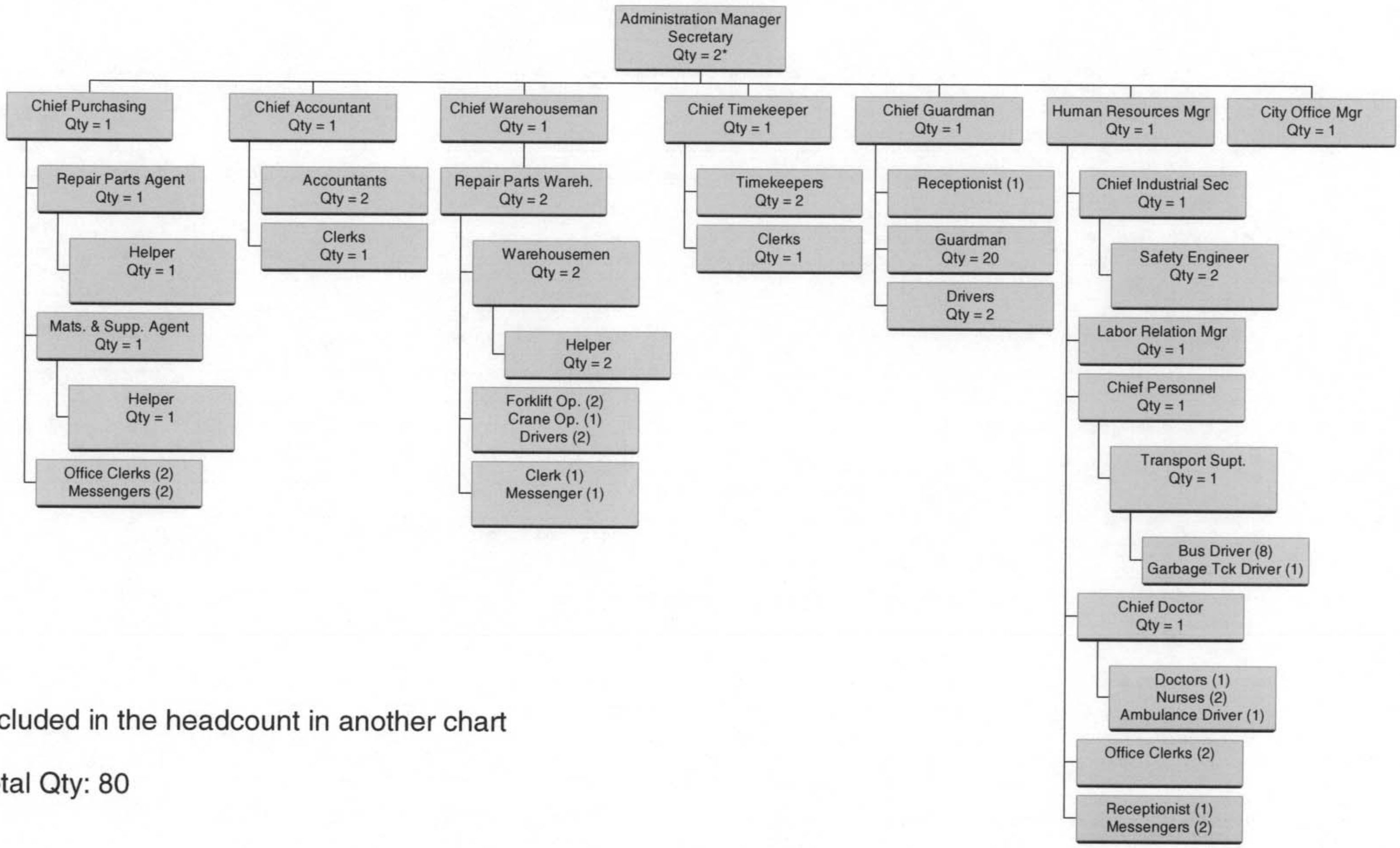
Administration
Channel Excavation Contract



* Included in the headcount in another chart

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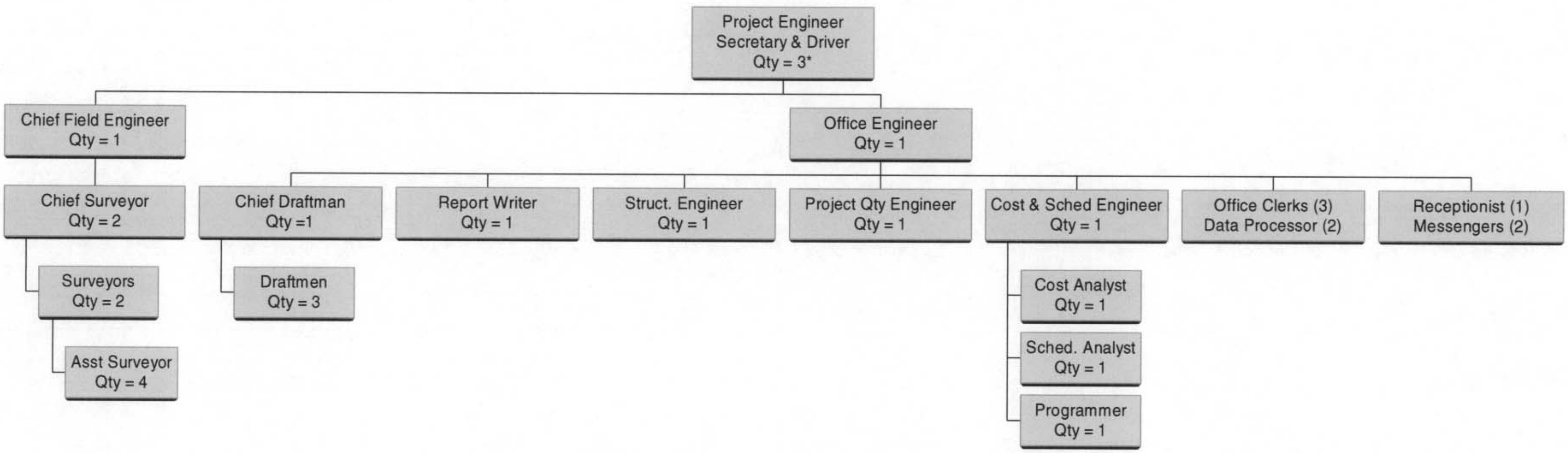
Construction Engineering
Channel Excavation Contract



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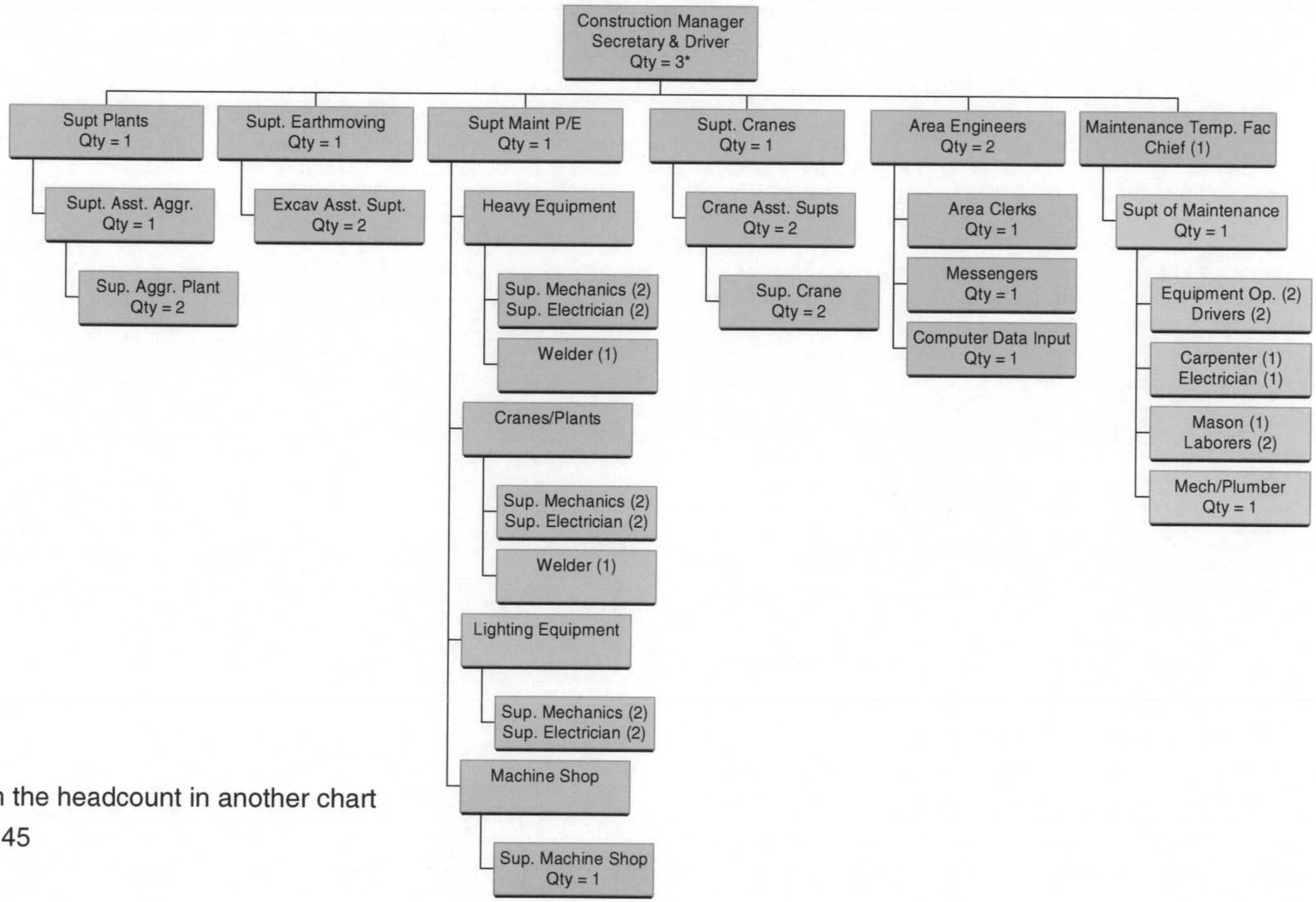
Total Qty: 29

Construction Supervision
Channel Excavation Contract



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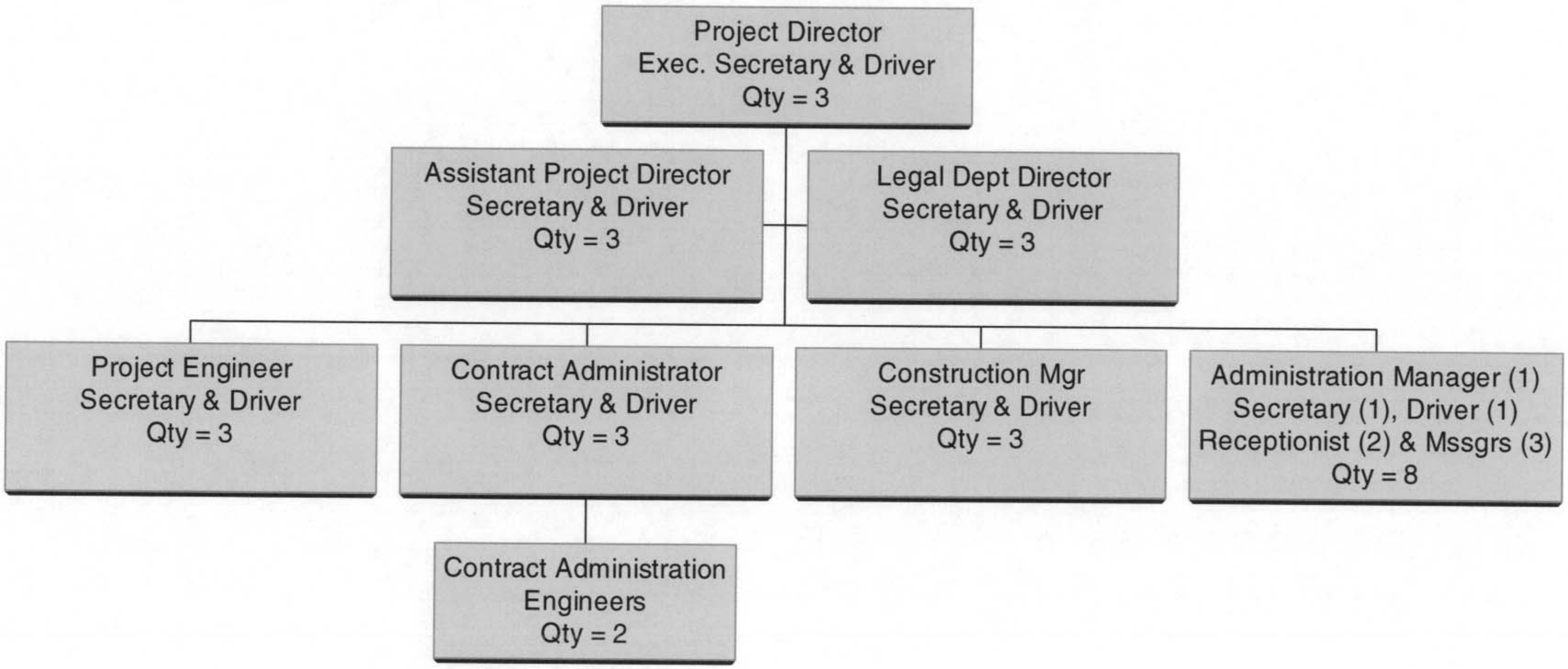
Total Qty: 45

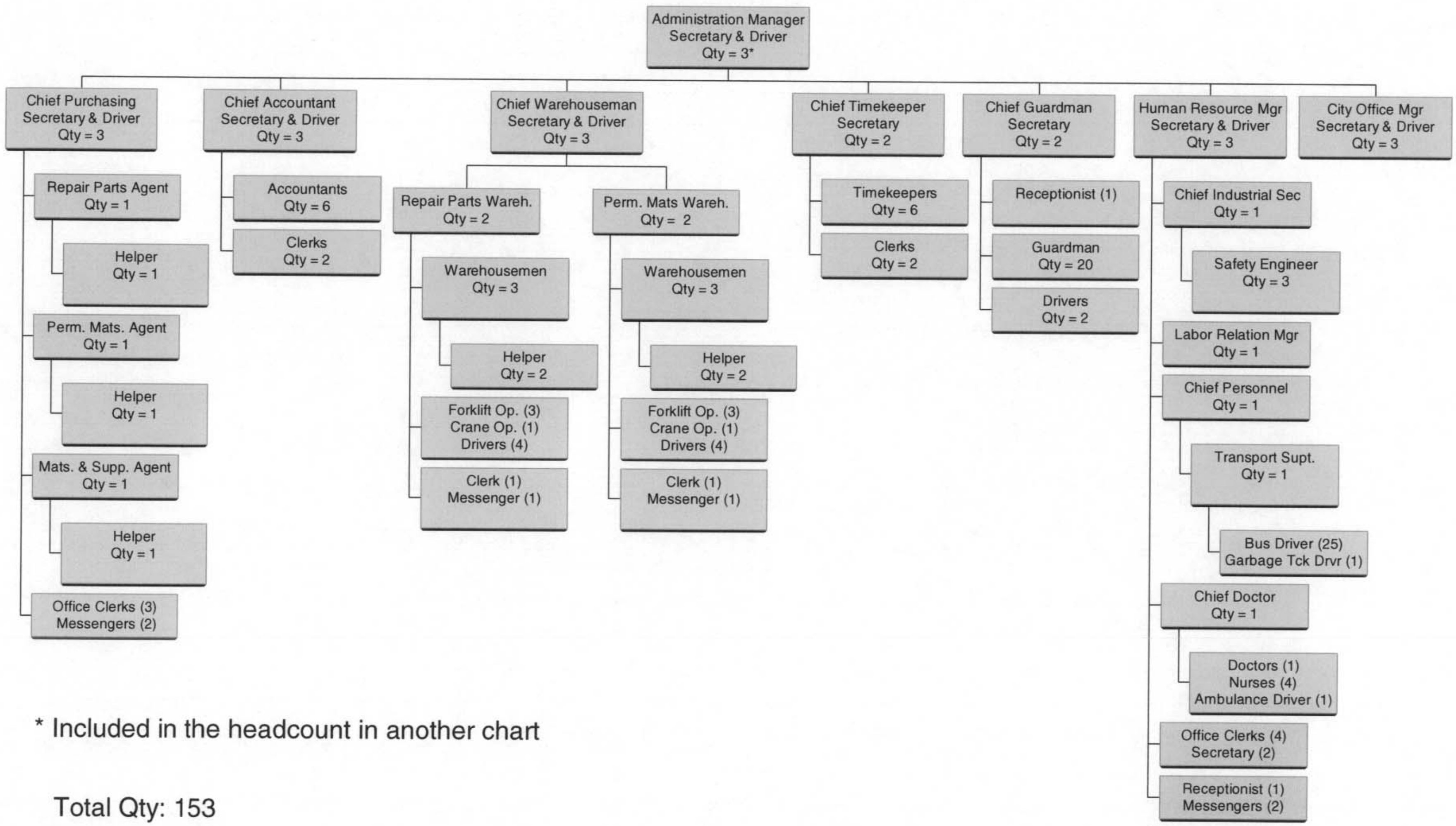
Atlantic Side – Locks Contract

General Administration
Atlantic Locks Contract



Total Qty: 28

Administration
Atlantic Locks Contract



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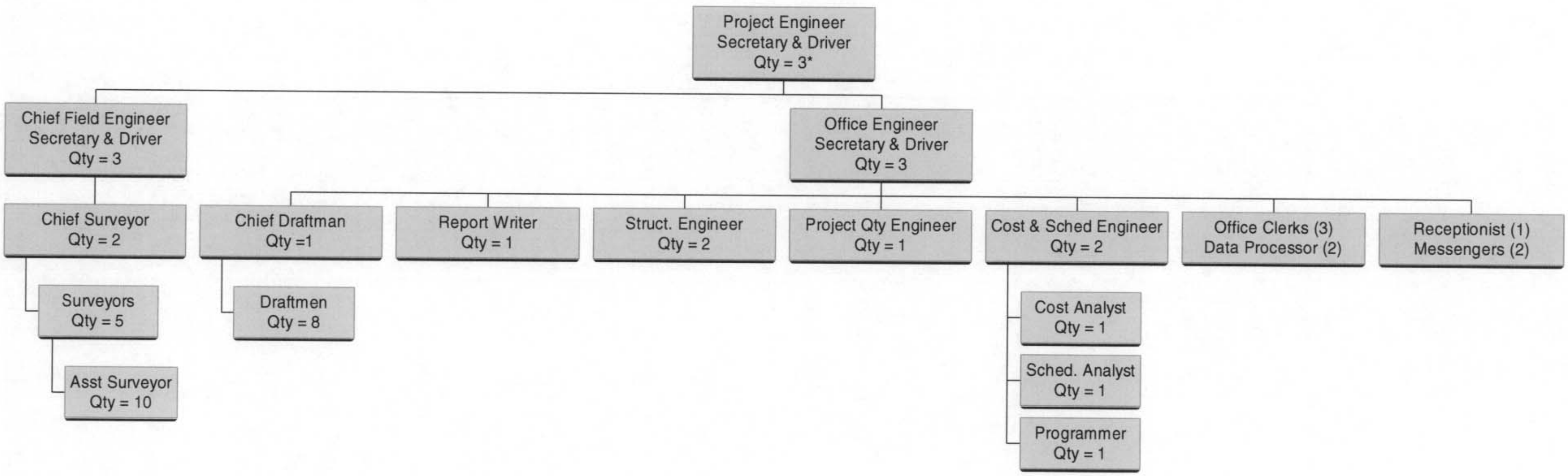
Total Qty: 153

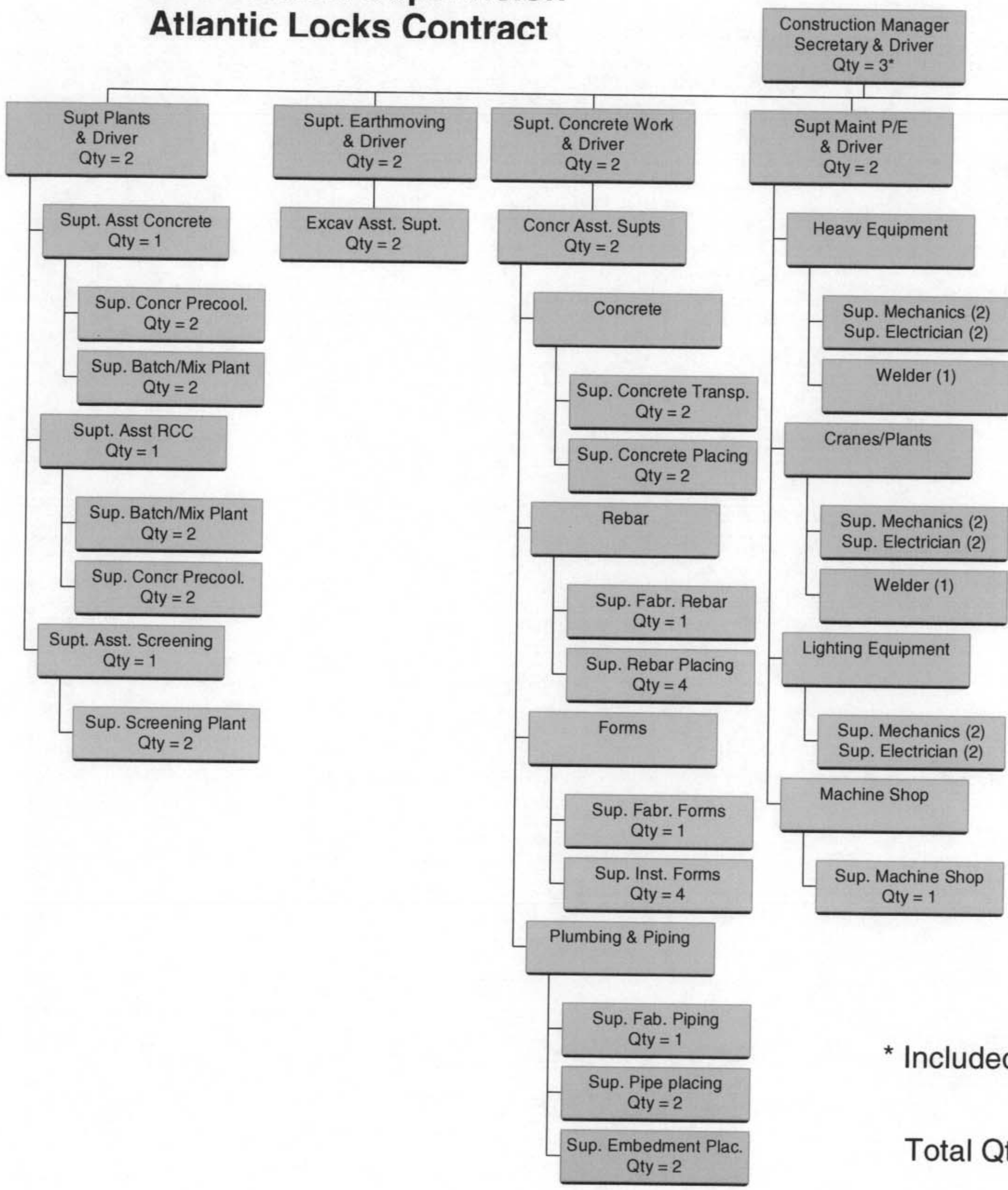
Construction Engineering
Atlantic Locks Contract

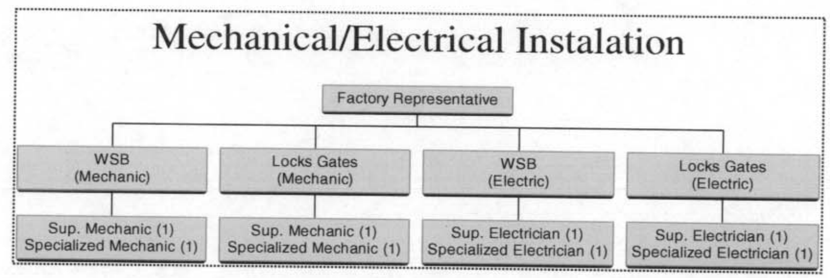


* Included in the headcount in another chart

Total Qty: 49

Construction Supervision
Atlantic Locks Contract

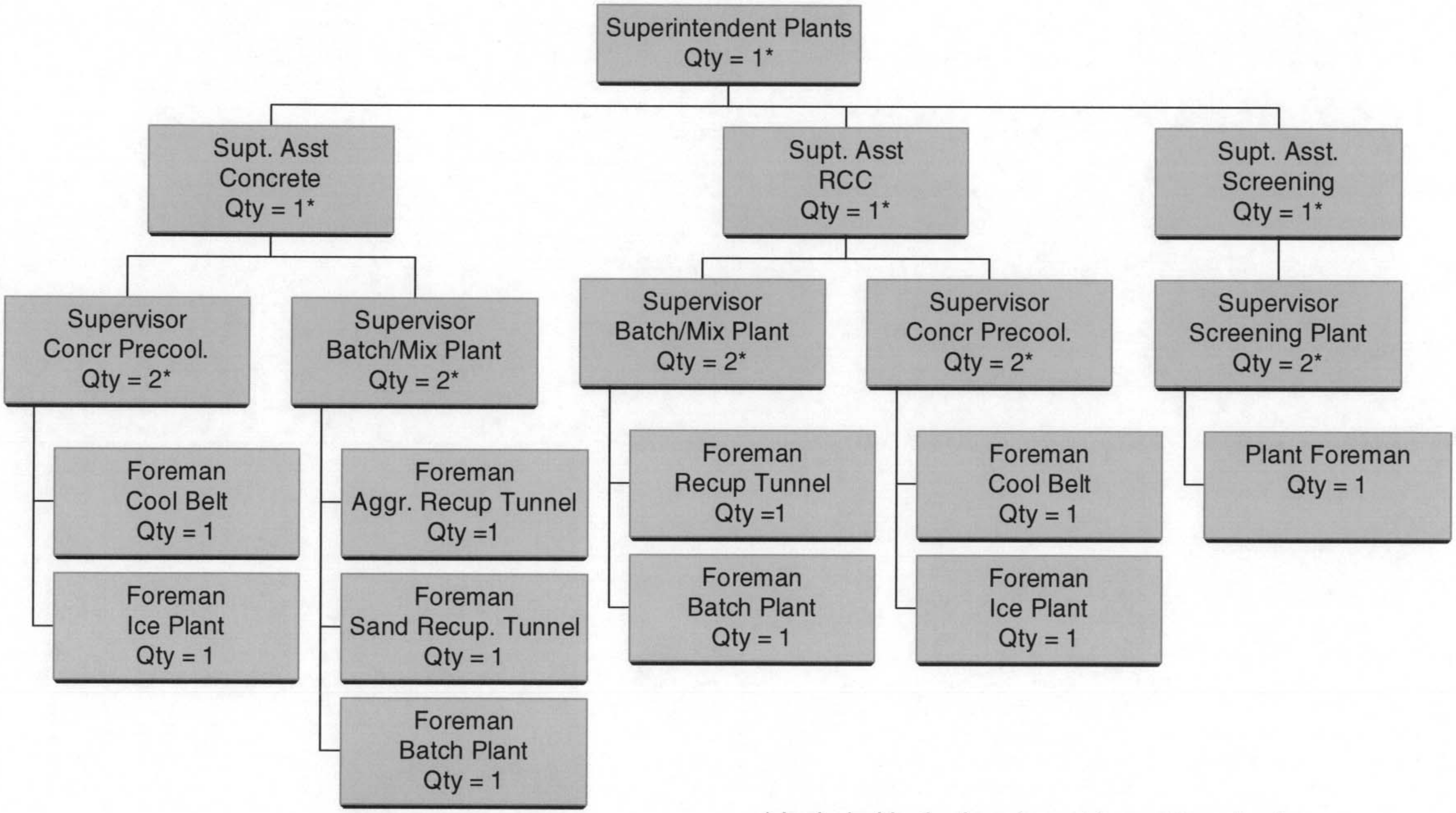




* Included in the headcount in another chart

Total Qty: 123

Plants
Atlantic Locks Contract



* Included in the headcount in another chart

Total Qty: 10

PACIFIC LOCKS

1 Pacific Locks – Background

The first attempt to build a third lane of a larger lock at the West side of the existing twin lock of Miraflores was performed in 1940. The town of Cocoli was built for workers involved in the potential new lock construction and excavation works to build a 2-Lift lock to connect the Pacific Ocean entrance channel to Miraflores Lake16 meters above. At the final stage of the excavation works the project was halted when the United States entered the Second World War.

The geological structure of the area to place two separate locks at Miraflores (2-Lifts) and at Pedro Miguel (1-Lift) was explored and all of the design drawings and physical scale models were performed. Five years earlier Madden Dam was completed to regulate and store more water for the existing and for the new third lane of lock.

Works for the third lane did not resume after the war ended. In the period of 1945 through 1970, the US administration considered many alternatives for expanding the existing lock canal, most of them considering a sea-level canal to avoid the danger of enemy attacks to the locks and water impounding structures. Due to the immense excavation works to achieve this type of canal, even nuclear blasting of the trench was considered. In 1993 the Canal Alternatives Study (CAS), a multinational commission financed by the governments of the US, Japan and Panama recommended the construction of a new larger 2-Lifts twin lock between the ocean and Gaillard Cut, West of the existing Miraflores lock and a similar structure at the Atlantic side.

The latest conceptual design is a single lane, 3-lift lock with 3-Water Saving Basins per lift located West of the existing lock complex.

1.1 Pacific Locks – Assumptions

Assumptions made in the development of the cost estimates and schedules for Pacific Concept Level Designs for the Post-Panamax locks are:

- Material excavated from the Pacific site, which is not utilized at the locks or Cocoli River sites would be hauled to the UXO site.
- The Cocoli town site would be available for use by the contractor to set offices and staging area.

1.2 Required Land Acquisitions

A construction project of this magnitude would require facilities for the contractors, such as offices, shops, warehouses, and other operating infrastructure. To accommodate all of these facilities on the Pacific side, the ACP would need to acquire 231,561 square meters of land in Cocoli, including 89 existing buildings that are presently under concession with ESPANAM Iberoamerica, S.A., awarded by the Interoceanic Region Authority for the development of industrial activities. However, the ACP's compatibility authorization establishes that this concession could be terminated at any time per (a) Government of Panama request, or (b) determination by the ACP that development of the estate is not compatible with the continuous and efficient management, operation and maintenance of the Canal.

Although the ACP may not need to pay the concessionary for this land, in this study we are assuming that the areas would be purchased. According to the Panama General Controller's Office, the cost of the land across the street from the ESPANAM concession (ID 10000-035) is one dollar per square meter (US$ 1.00/m^2). Using this price as reference, the total cost of acquisition would be US$ 231,561.00.

Appendix A includes a description of land in Cocoli not presently owned by the ACP. This information was taken from the Geographic Information System (GIS).

1.3 Schedule

Total estimated time for the Pacific locks construction is six years. Excavation, concrete work, and electro-mechanical work are the major items that could have an impact on the construction schedule. Mobilization for excavation and concrete work begin as soon as the contract is awarded.

Some work at the site could begin during the excavation mobilization phase if the main contractor subcontracts the work to local companies, or if the ACP contracts the items separately, removing them from the main contract. Activities that could be included during these early stages are: road relocation and repairs, Miraflores Swing Bridge rehabilitation, construction of a railroad extension for transportation of aggregate and crushed stone to the Atlantic, cofferdam construction at Miraflores Lake and Cocoli River, Cocoli River diversion, reinforcement of the southern cofferdam for heavy traffic, dewatering of the 1939 excavation, preparation of areas for crushing and batching plants, and clearing of areas for heavy equipment platform and shops.

It is assumed that the earliest the contractor could start excavation at the site is six months into the mobilization. At this point, it may be possible for the contractor to have excavation equipment operational.

Excavation would begin at the lower chamber and proceed upstream; the Pacific approach would be excavated after the upper chamber and Gatun approach. Total time estimated for locks excavation is 39 months.

The plant (aggregates, RC, RCC, ice, pre-cooling, etc.) would arrive one year into mobilization for assembly and testing; the concrete work is scheduled to begin six months later when excavation has advanced to about half the middle chamber. Concrete work would begin in the lower chamber and proceed towards the upper chamber, staying 200m behind the excavation work.

To properly schedule equipment use, the work would be divided into four main activities: lock heads, lock walls, water saving basin conduits, and water saving basins.

Equipment used for each of these activities in the lower chamber would be used successively in the middle and upper chambers. Estimated time for concrete work is 45 months.

The cost estimate and schedule assumes that gates, valves, and bulkheads would be designed, fabricated and transported to the site under a separate contract. The electro-mechanical installation work could begin when the civil work is completed in a given chamber. Installation time for the main culvert valves varies between 14 months for the upper valves and 29 months for the lower valves. Installation time for water saving basin valves varies between 8 months for the upper chamber and 27 months for the lower chamber.

Time estimated for valve installation depends on whether the concrete work is ready for installation of the electro-mechanical equipment. Float time is reduced for each successive chamber, with the installation in the upper chamber becoming part of the critical path. All concrete work must be completed and valves (main culvert and water saving basins) set in place before the lock gates can be installed.

Lock gate installation requires the flooding of the chambers. Since high tide in the Pacific reaches the upper chamber, all work on the chamber floors must be completed before flooding. Sea gates (gates in the lower chamber) could be installed at ocean water levels. However, to install the gates in the middle and upper chambers, the lower gates need to be closed to retain the water. Then, water would be siphoned into the chambers until obtaining the depth required for the installation of the respective gates. After all the gates and valves are installed and operational, a 15-day testing and commissioning period is required before the lock can be operational.

2 Constructibility Assessment

Assessing the constructibility of the Pacific locks, the Cost Team determined that the construction of the design proposed by the Consorcio Post Panamax was straightforward and could be built with only some small modifications. Designers presented an option to place RCC or gravel fill between the layers of the WSB conduits. Due to the difficulty in placing RCC in this area, a gravel fill was assumed instead of RCC for the purpose of this estimate. Additionally, a three-meter high RCC layer was designed on the conduits surface, and RCC was placed over the conduit that crosses the chamber from the east wall to the west wall. To ease concrete placing, the use of conventional reinforced concrete was assumed instead of RCC. This concrete volume would is included in the water saving basin floors concrete item. It was also assumed that providing a 2m thick filter layer and using regular fill for the remainder of the work could eliminate a significant portion of the granular fill.

The team identified elements that were not included in the requirements for the concept level design, but which must be included in the next design level. Some of the items to be addressed are:

- Details of inlets and outlets
- Discharge from approach channel through outlets
- Design of a cofferdam between Miraflores Lake and proposed locks
- Design of a cofferdam and diversion of Cocoli River
- Cofferdam and cutoff wall at southwest end of Pedro Miguel Locks

- Reinforcement of the Saddle Dam at Northwest end of Pedro Miguel Locks and construction of a cutoff wall
- Construction of spur line from PCRC line to locks site
- Rehabilitation of Miraflores Bridge from rail line to lock site
- Water treatment plant for locks complex
- Relocation of Borinquen Highway
- Relocation of utilities
- Design of roads between existing Miraflores Locks, new Post-Panamax Locks and existing Pedro Miguel Locks
- Environmental Mitigation
- UXO site cleanup

3 Relocation of Existing Infrastructure

3.1 Water Utilities

3.1.1 Water Utilities Relocation Cost Estimate Assumptions

The total estimate:

a. Does not include cost of transportation, insurance, freight of materials from the place of manufacture to Panama, and Panama taxes, but does include overhead and profit.

d. Envisions conceptual water utilities relocation basic design coordinated with Aqueducts Section (SIEA).

- **Temporary Relocation**

Both the existing ACP 0.4-m.φ potable water lines and the IDAAN 0.6-m.φ potable water line must be temporarily relocated to an approximately 2.65-Km long loop for the 0.4-m.φ line, and a 3.2-Km long loop for the 0.6-m.φ line, around the existing 1939's lock excavation site's north plug and over the planned Cocoli River cofferdams during the civil work construction period for the new locks. When civil work is completed, both potable water lines must be permanently relocated to the new locks' water utilities cross-under.

- **Permanent Relocation**

The permanent water utilities relocation distance is estimated at approximately 1.5-Km., about one half the temporary relocation loop distance for the 0.6-m.φ line. The permanent relocation is to be performed by installing new permanent potable water piping through the new set of locks' water utilities cross-under. The cost would be approximately two times the cost per meter of the temporary relocation. The total permanent relocation cost for the Pacific side locks water utilities does not include contingencies for possible unforeseen mechanical accessories or fittings required to complete the installation.

- **Water Requirements**

Total Estimated Water Demand for Pacific Side Locks

± 2.086877 MGD Total Estimated Daily Industrial Usage Water Demand
± 0.190225 MGD Total Estimated Daily Human Consumption Water Demand
± 2.277102 MGD Total Estimated Daily Water Demand

Refer to Appendix E for backup information

3.2 Electrical Utilities

3.2.1 Electrical Utilities Relocation Cost Estimate Assumptions

The total estimate:

a. Includes cost of transportation, insurance, freight of materials from the place of manufacture to Panama, overhead and profit, but no Panama taxes.

b. Envisions conceptual electric utilities relocation basic design coordinated with SIEE. This design does not include the requirement of an additional substation.

- **Temporary Relocation**

The existing ACP's 12-KV circuits (KX, KW, MR, MT & ML), the telecommunications circuit and the 44-KV circuit (Line 418) must be temporarily relocated to an approximately 3.0-Km long loop around the existing 1939's lock excavation site's north plug and the planned Cocoli River cofferdams during the civil work for the new locks. When civil work is completed, the six (6) electric power and the telecommunications circuits must be permanently relocated through the new locks' electric utilities cross-under. Temporary relocation of all circuits would be done above ground on wooden or concrete poles with the capacity and dimensions required to safely uphold the electric circuits' weight and load.

For cost estimating purposes, it was assumed that two (2) standard sets of poles would carry two (2) 12-KV circuits per set and that one (1) set of poles shall be reinforced to carry the main 44-KV circuit and one (1) 12-KV circuit. One (1) of the sets of poles would also carry the telecommunications circuit. The total temporary relocation cost for the Pacific side locks electric utilities includes telecommunications circuits and any electrical equipment contingencies.

- **Permanent Relocation**

The permanent electric utilities relocation distance is estimated at approximately 1.5-Km., about one half the temporary relocation loop distance of approximately 3.0-Km., but the permanent relocation is to be performed by installing new permanent wiring through the new set of locks electric utilities cross-under. The cost is estimated at approximately four times the cost per meter of the temporary relocation. The total permanent relocation cost for the Pacific side locks electric utilities includes contingencies for telecommunications circuits and any unforeseen requirements like new switchgear and accessories needed to provide the service.

- **Electric Power Requirements**

Total Estimated Electric Energy Demand for Pacific Side Locks:

± 5.20 MVA Total Estimated 100% Average Electric Energy Demand
±24.10 MVA Total Estimated 80% Average Electric Energy Demand
± 0.51 MVA Total Estimated 60% Average Electric Energy Demand
±29.81 MVA Total Estimated Electric Energy Demand per Lock Set

Refer to Appendix E for backup information

4 Excavation

4.1 Basic Assumptions for the Excavation Work

To facilitate drainage and dewatering, excavation of the locks chambers and locks heads would start from the south (Pacific) end and progress northward until reaching the north corner of the Gatun approach wall. After that, the excavation for the Pacific approach wall would be done.

Water saving basin excavation would be done parallel to the excavation of lock chambers.

The Gatun approach wall, the middle chamber and the lower chamber would be founded on basalt, whereas part of the upper chamber and part of the Pacific approach wall would be founded on La Boca formation. Only lockhead 2 would be founded on La Boca formation. The remaining three lockheads would be founded on basalt. Water saving basins would be founded on basalt except for the one that feeds the upper chamber, which would be excavated partly in La Boca formation.

The excavation of basalt and sound agglomerates (Pedro Miguel formation) would require drilling and blasting, whereas weathered rock, La Boca formation and Cucaracha formation would be ripped.

Almost the entire sound basalt coming from the required locks and approach wall excavations would be stock piled, crushed and used as aggregate material for concrete production. The overburden and La Boca materials would be disposed or used for construction of temporary cofferdams. Part of these materials could be used to fill the 1939 excavated trenches.

All excavated materials not suitable for the production of concrete aggregates, backfilling or for use in the construction of temporary structures would be transported to the disposal site. The selected disposal site is located northwest of the alignment channel, about 2 km from the centroid of the new locks project. This area is known as the post-diversion Cocoli Valley.
The excavation of the alignment channel from Culebra Cut to the Gatun approach wall would be executed as a separate contract and would be phased in several fronts. Part of the sound basalt would be stockpiled for use as aggregate for concrete in the Atlantic locks construction, but most of the excavated material would be transported by road to a selected disposal site.

4.2 Access and Haul Roads

The main access area to the project site is from the Inter-American Highway through the Brujas-Borinquen road to the Cocoli area. The distance from the Inter-American Highway is about 3 km. Alternate access with some restrictions would be from the new Centenario Bridge to the west side of the alignment channel and over the existing Miraflores Bridge to the east side of the new locks.

During construction, the contractor would be required to rehabilitate several access roads to the different work areas and to haul materials.

Most of the materials coming from the excavation of the locks chambers, the approach walls and the water saving basins would be used in the aggregate production plant, construction of temporary roads and cofferdams, backfills and to fill up existing 1939 excavations.

Average distances to the different areas are:

-From locks chambers to aggregate processing plant- 2.5 km.
-From locks chambers to disposal site-2 km.
-From locks chambers to rock stock pile-1.5 km
-From aggregate processing plant to batching plant-1 km.
-From main access to batching plant-1.5 km
-From main access to aggregate processing plant-2.5 km
-From batching plant to locks chamber-1.8 km
-From batching plant to water saving basins-1.0 km.
-From alignment channel to disposal area – 5.0 km.
-From alignment channel to rock stock pile- 1.0 km
-From Pacific approach channel to UXO disposal area-9.0 km.

The existing Borinquen Road, which provides access to the west side of Miraflores and Pedro Miguel locks, needs to be relocated through the island that would be formed between Miraflores Lake and the new alignment channel to the Post-Panamax locks. This road is about 5.5 km long from main access to project site. This road would be used for material hauling during construction of the new locks and access for operation of the existing locks.

4.3 Cofferdams

The construction of the locks in dry conditions would require the handling of the watercourses and isolation of the work from the surrounding water bodies. To accomplish this, it would be necessary to build a cofferdam to handle the water from the Cocoli River which discharges into Miraflores Lake just upstream of the new locks alignment. This cofferdam would be a permanent structure and would divert the river to an open channel. This channel would lead water southward to the Pacific approach channel.

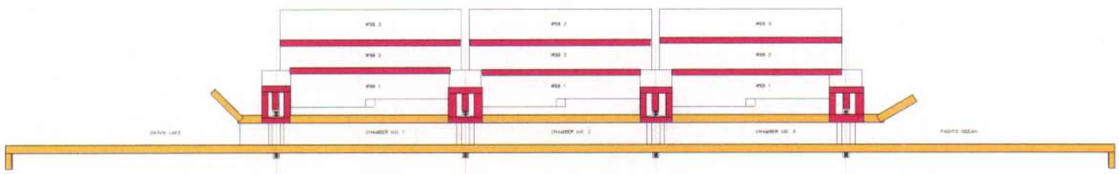
Another cofferdam is required to isolate construction work northeast of the new locks from Miraflores Lake. This cofferdam would be located at the mouth of the Cocoli River where it flows into Miraflores Lake.

An existing cofferdam located at the south end of the new locks alignment would be used to isolate the work from the Pacific Ocean. This structure would need to be enlarged and strengthened to uphold heavy traffic.

5 Concrete Work

- **Lock walls**

CPP submitted a conceptual design for a Post-Panamax Lock system that consists of the following concrete structural elements: three lock chambers 423.8 m long; three water saving basins per lift, each one with upper, intermediate, and lower levels; four lockheads; a rolling gate system for each lockhead; and approach walls for each entrance to the locks. Designers studied two options for concrete construction: (1) the use of conventional reinforced concrete (RC) for all lock elements, and (2) construction of lock structures using a combination of RC and roller compacted concrete (RCC). The latter option was selected for the purpose of this cost estimate and schedule for being more economical. The chamber wall and the approach walls were designed for a combination of RC and RCC, and the remaining elements of the walls were designed for RC. The lockheads and the water saving basins walls were designed for RC. Figure 6.1 shows the elements that would be built entirely with RC, as well as the elements that would use a combination of RC and RCC.

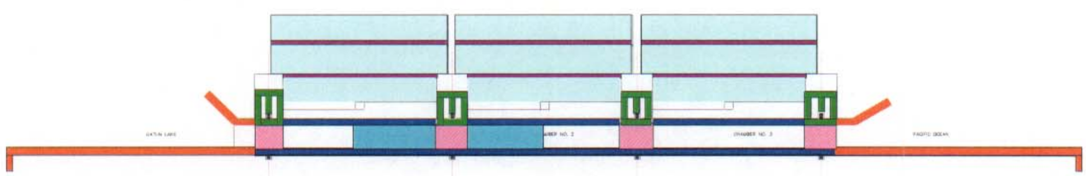


- Reinforced Concrete
- Reinforced Concrete and Roller Compacted Concrete

Figure 6.1 Concrete Placing

5.1 Concrete Volumes

The locks were subdivided into five main sections (Approach Walls, Lock & Gate Chamber Walls, Lock & Gate Chamber Floors, Water Saving Basin Walls, and Water Saving Basin Floors) to calculate concrete volumes required for the project. These volumes were calculated by multiplying the cross-sectional areas of each section by their effective length. This procedure was done for every different cross-section designed. Figure _6.2_shows the location of the different lock sections.



- Gate Walls
- Chamber Walls
- Approach Walls
- Chamber Floors
- Gate Floors
- Water Saving Basins Floor
- Water Saving Basins Walls

Figure 6.2 Concrete Cross-sections Locations

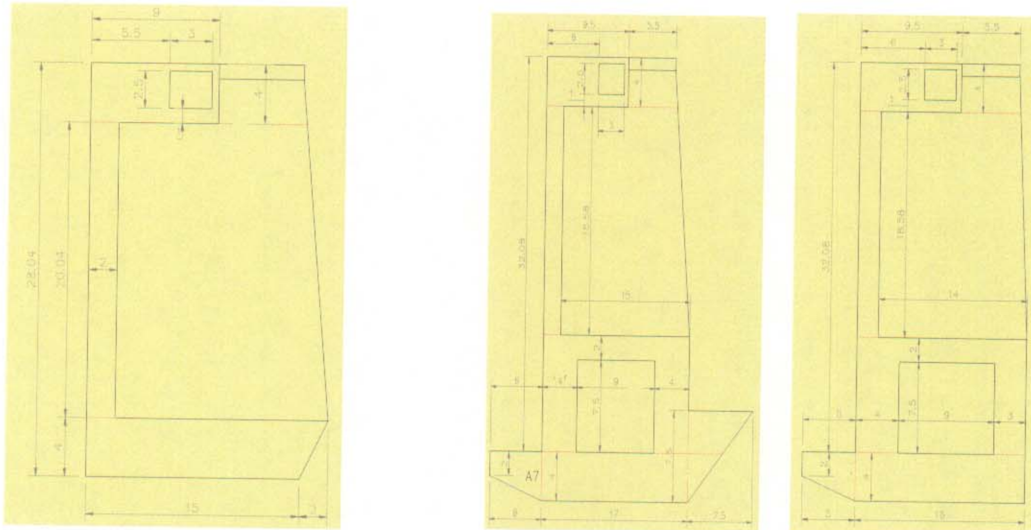
Concrete volumes for approach walls were calculated from the cross sections provided by the designer. Due to the changing topography and different soil formations found at the site proposed for the construction of the Pacific Locks, different wall sections were designed: one for Basalt formation, one for La Boca formation, one for the Gatun approach channel, and another for the Pacific approach channel. The difference between Basalt formation and La Boca formation designs was the degree of the backfill ratio and the width of the wall base, while the Gatun and the Pacific approach channels differ in the height of their walls.

Each lock chamber has three identical water saving basins that vary only in the height of their walls, which conform to the topography of the site. They have three major elements: walls and wall foundations; conduits; and valve chambers. Valve chambers, conduits, intakes, and walls were designed in reinforced concrete. For details of concrete volumes for each of these elements refer to Appendix B. Table 6.3 shows total concrete volumes.

	RC (m^3)	RCC (m^3)	Totals (m^3)
Approach Walls	200,108.16	465,224.97	665,333.13
Lock/Gate Chamber Walls	1,305,506.13	696,330.21	2,001,836.34
Lock/Gate Chamber Floors	148,830.63		148,830.63
Water Saving Basins Walls	415,015.95		415,015.95
Water Saving Basins Floors	232,959.15		232,959.15
	2,302,420.01	**1,161,555.18**	**3,463,975.19**

Table 6.3 Concrete Volumes for Pacific Post Panamax Locks

Designers provided an option for placing RCC or gravel fill between the layers of the WSB conduits. Due to the difficulty in placing RCC in this area, a gravel fill would be assumed instead of RCC. Additionally, a three-meter high RCC layer was designed on the surface of the conduits and over the conduit that crosses the chamber from east wall to west wall. Due to placing difficulty, it was assumed that conventional reinforced concrete would be used instead of RCC. This concrete volume would be assigned to the water saving basin floors' concrete item.



Approach Wall

Locks Chamber Wall

Figure 6.3. Typical Cross Section.

5.2 Cold Joints

Calculations for the horizontal and vertical cold joints are directly related to the concrete placement method and the time between each concrete placement (Seventy-two hours are required between placements at a cold joint). Because of the placement method chosen (2 meter lifts 30 meters in length, placed staggered two at a time), there would be 6 horizontal cold joints and 15 vertical cold joints in the bottom section with the culvert. And 2 horizontal cold joints on the chamber top slab. Table 6.5 summarizes cold joint quantities computed in this study.

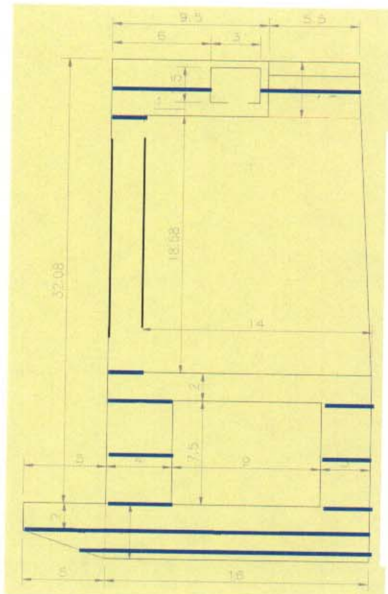


Figure 6.5 Horizontal Cold Joints

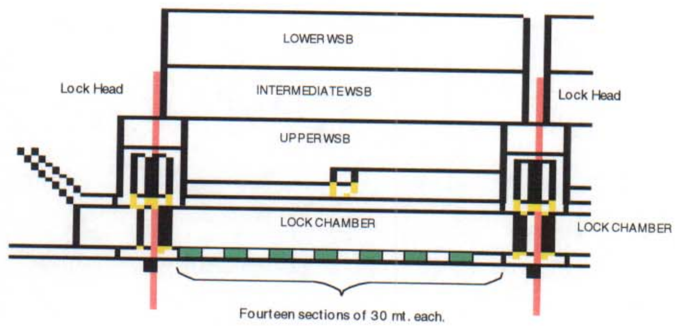


Figure 6.4 Vertical Cold Joints

5.3 Formwork

Formwork amounts for the Pacific lock walls were calculated based on a construction scheme that considers that RCC (roller compacted concrete) would be placed simultaneously with the RC (reinforced concrete) face of the chamber wall. Because of this construction method, forms would only be required on the outer face of the chamber walls, to form the culverts, machinery and cable galleries, and water saving basin walls.

Several types of forms must be used to comply with the wide range of shapes and construction schemes found in this project. Following is a list of the types of forms and their assumed applications.

- **Off rock:** This type of form is used to come off the ground. It only goes to a height of about 50 cm above the rock and is used a single time because the bottom edge has to be shaped to fit the rock contour. It would probably be used to form the first sections of the approach, lock, and gate walls, as well as the foundation of the water saving basin walls.

- **Starter**: Used to start from floor and joints and goes up to a height of 3m. They would be used mainly for the approach, lock, and gate walls. These could be used 30 times.

- **Cantilever wood**: This type of form is employed for corners and details. It would most likely be used for certain areas encountered on the gate recess walls. This type of form could be used 4 times.

- **Cantilever steel**: Consists of individual panels that are fixed only by their bottom edge. They are used above the starter form and can be placed all the way to the top. Generally, they can be used between 30-100 times. In this project, they might be used in some areas of the gate recess walls, water saving basins, and culverts, machinery and cable galleries.

- **Cantilever gang steel**: Similar to cantilever forms, except that they usually are 4-panel modules (the number of panels in a module depends on the capacity of the crane), have hydraulic pistons to facilitate their removal and a hopper for concrete placing. They would be used for the approach, lock, and gate walls.

- **Construction joint wood**: These forms are used in areas where there are construction joints. They are only used once.

- **Soffit steel**: Used for horizontal overhead areas. They can be used between 30-100 times, and would most likely be used in some areas of the gate recess walls, and on the culverts and machinery and cable galleries.

Areas	Type of Concrete Form
Approach walls and chambers	
Front wall	Off rock, starter, cantilever gang steel
Back wall	Off rock, starter, cantilever gang steel
Operating gallery	Cantilever steel, soffit
Electrical gallery	Cantilever steel, soffit
Culvert	Cantilever steel, soffit, special
WSB	
Walls	Off rock, cantilever steel
Conduits	Special
Gate Bays	
Front wall	Off rock, starter, cantilever gang steel
Back wall	Off rock, starter, cantilever gang steel
Gate recess	Cantilever steel, cantilever wood
Machinery and cable galleries	Cantilever steel, soffit
Valve slots	Cantilever wood
Bulkhead slots	Cantilever wood

Table 5.1. Type of forms needed depending on construction area

Type of concrete form Summary	Reuse	Contact Area m2	Fabr/Buy m2
Cantilever Forms - Wood	4	10,598	2,650
Soffit Forms - Steel	30	73,707	2,457
Cantilever Steel Forms - Metal	30	258,730	8,624
Cantilever Gang Forms - Metal	30	190,610	6,354
Special forms for culvert	18	81,851	4,547
Form over the rock - Wood	1	7,266	7,266
CJ Forms - Wood	1	99,306	99,306
Total square meters		**722,068**	**131,204**

6 Steel Reinforcement

6.1 Reinforcing Steel Quantities

The Pacific design includes reinforcing steel quantities required for the locks. With the reinforcing steel quantities from the different parts of the locks a reinforcing steel/concrete ratio (kg of steel/m3 of concrete) was calculated and was applied to the concrete quantities calculated by the ACP to determine the reinforcing steel by area.

Part of the locks	Ratio (kg/m3)
Approach Wall	1.69%
Lock Walls	2.91%
Gate bay	8.04%
Floors	3.06%
WSB	7.83%

Aplying the ratios to the concrete quantities the results are:

Pacific	Reinforce bars (tons)
Approach Wall	10,157
Lock Walls	39,042
Gate bay	60,071
Floors	2,369
WSB	30,133
Total	**141,773**

7 Concrete Placing Methods

Concrete placing would begin 12 months after excavation starts. By then, Chamber 3 excavation would be completed and excavation of Chamber 2 would be 50%advanced. Four (4) elements would be built simultaneously in Chamber 3: lock wall culverts, lockhead 3, lockhead 4, and WSB conduits.

7.1 Lock Wall Culverts

Equipment used for the construction of Chamber 3 lock wall culverts, would consist of four (4) tower cranes. The tower cranes would handle the rebar and forms and concrete placement would be accomplished using one (1) 24" Tower Belt. After Chamber 3 lock wall culverts are completed, the equipment would be transferred to Chamber 2 to initiate lock wall culvert construction.
Once Chamber 2 lock wall culverts are completed, the equipment would be transferred to Chamber 1. The equipment transfer time from one chamber to another would be two (2) months.

7.2 Water Saving Basin and Conduits

Chamber 3 – of the Water Saving Basin Conduits (WSB) would be built using two tower cranes and 8" concrete pumps. After the conduits are completed, the equipment would be transferred to the Chamber 2 WSB and after than to Chamber #1. The allowed transfer time between chambers is one month.

Valve House #3 would start immediately after the WSB conduits are completed. One tower crane would be used for its construction. Once completed, the equipment would be transferred for the construction of valve house in Chamber #2, and then to Chamber #1. The allowed transfer time between chambers would be one month.

7.3 Lockheads

The construction schedule shows that Lockheads 3 and 4 would start simultaneously after the excavation of Chamber 2 is 50 % advanced; this is mainly due to safety considerations since blasting operations would be very close to lockhead construction work. Two (2) tower cranes and one (1) 24" tower belt would be used for concrete placement of each lockhead. One (1) tower crane would handle rebar and forms on the Northern lockhead, while the second tower crane would handle the rebar and forms on the Southern lockhead. The tower belt would be used to place the concrete on both the Northern and Southern sides of the Lockhead. After work on the lockheads is completed, the equipment used to build lockhead 3 would be transferred to lockhead 1 and the equipment used to build lockhead 4 would be transferred to lockhead 2. Transfer time for each move would be two months. The same procedure would be used in the construction of lockheads 1 and 2.

7.4 Lock Walls

The scheduled construction time for lock walls includes placement of both conventional reinforced concrete and roller compacted concrete. Two (2) tower cranes with buckets would be used for the conventional concrete placement and the same tower cranes would handle rebar and forms. RCC would be discharged from the transfer hopper to 35-ton off-highway end-dump trucks. Dump trucks would haul and end dump RCC in the placement area; afterwards RCC would be spread in 30cm layers using a bulldozer and then rolled using vibrating rollers. After chamber 3-lock walls are built, the same equipment would be transferred to the Gatun Approach Wall. Once completed, it would be transferred to chamber #2 and then to the Pacific approach wall, and lastly to Chamber #1. Additionally, two (2) Creeter Cranes would help with concrete placing on the approach walls. Transfer time for the equipment is two months.

7.5 Top Slab on Walls

Lock wall construction described above does not include the top slabs. To start the construction of the top slab, the placement of the lock walls must be completed. The same two (2) Creeter Cranes that were placing concrete in the approach walls would be used for the top slabs. The construction sequence for the top slab is: Gatun approach wall; Chamber #3, Chamber #2, Pacific approach wall, and the last top slab to be built would be in chamber #2. The schedule allows two months for each transfer.

8 Electro-mechanical Equipment

8.1 Rolling Gates

- **Description**
  Rolling gates are single-leaf box-like steel structures that block the whole lock width, and have a recess area perpendicular to the lock wall into which the gate retracts when opened. These gates are used where large opening widths are to be closed. Rolling gates that span over 61-meters, required for the ACP Post-Panamax locks, exist in Berendrecht Lock in Antwerp, Belgium, which has gates that span 68-meters (see figure 1.1). The recess can be sealed from the chamber, and dewatered for gate maintenance or repair. The gate recess must be equipped with a slot bulkhead and pumping system to enable dewatering of the gate recess.

Figure 7.1. Rolling gate at Berendrecht Lock

For the Pacific Locks three-lift design, 8 rolling gates would be needed. Table 7.1 shows their required estimated dimensions and weights:

Gate ID	Length (m)	Width (m)	Height (m)	Weight (tons)
T1 (2 ea.)	63	7	22.7	1900
T2 (2 ea.)	63	11	30.7	3000
T3 (2 ea.)	63	11	30.5	3000
T4 (2 ea.)	63	12	31.7	3100

Table 7.1. Rolling gates estimated dimensions and weights for the Pacific Locks

The gates are supported on rolling carriages. The arrangement of the support follows the so-called "wheel barrow" layout. This consists of a lower carriage that runs on rails on the sill, and an upper carriage running on cantilevers projecting from the gate recess walls. The upper carriage is used to transmit the driving force to the rolling gate.

The lock gate is operated by a wire rope winch system, which is connected on the upper carriage of the gate. The winch system consists of (1) two main driving AC motors of 300 kW each (one operating and one standby), (2) one smaller emergency AC motor of 30 kW, (3) one central gear box, (4) two secondary gear boxes, and (5) two rope drums of about 2 m in diameter (see figure 7.2). See Appendix D for a summary of the driving mechanism main characteristics. The two ropes are attached at one of their ends to the upper support wagon of the rolling gate via a set of pulleys, and at their other ends to the drum.

Figure 7.2. Rolling gate – Winch System

The gates operate smoothly with ramp up and ramp down cycles and Panama Canal gates were designed to open or close in 4 to 5 minutes.

- **Installation Procedure**

  A basic assumption of this cost estimating/scheduling effort is that the rolling gates would be constructed at an international shipyard that would have enough capacity to produce the gates in the required timeframe. They would be transported to Panama as a single unit either in a submersible type cargo vessel or floated vertically and towed by tugs.

  Once on Panama's Pacific side, the gates would be moored at the new locks entrance channel until the locks are built (including the installation of all culvert and conduit valves) and ready for their initial downstream flooding. It is assumed that by this time the technical building which houses the operating equipment would be completed, and that the winches, gears and motors would be installed and awaiting their final alignment and adjustment, which would be done when the gate is in place.

  When the Pacific side cofferdam is removed, the Pacific locks would be flooded to sea level. Then, the 8 gates would be moved to the lower level of the locks, where they would be secured. The first gates to be installed would be the T4 set. With the proper high tide, each gate would be swung into its recess with the help of tugs, winches and capstans and/or the floating crane Titan (or additional pontoons) to ensure the stability required during the swinging operation. Once inside their recesses, each gate's flotation would be increased so that the jacking support beams can be positioned; the gate would then be lowered and kept hanging from these beams. A 40-ton crane located on top of the recess would place the lower support wagon in position on the rails and under the gate with the assistance of divers. This same crane would install the upper support wagon, which must be attached to the gate structure. At this time the gate would be floated again to remove the jacking support beams. Then, adjusting its ballast the gate would be lowered, so that its effective weight can be distributed between the lower and upper support wagons. This would allow the wire rope cables from the winch system to be attached to the upper support wagons. With the cables installed, initial testing of the gate can start. A two-month time frame is scheduled for the installation of these two gates.

The installation of gates T1, T2, and T3 present a bigger challenge because, even at high tide, the water level is not high enough to enable them to float properly into their recesses. In order to start the upstream flooding that would allow floating of gates T1, T2, and T3, at least one of the gates from the T4 set must be operational, allowing it to be closed to hold the additional water that would be siphoned into the chambers from Miraflores Lake. When the proper water level is reached, the same procedure described for gate T4 would be repeated to install sets T3, T2, and T1. After each required upstream flooding occurs, a two-month timeframe is scheduled for the installation of each pair of these six gates. Before the gates final commissioning, an additional 15 days are scheduled for tests and installation adjustments.

8.2 Culvert and Conduit Valves

- **Description**

The components of a lock filling and emptying system are culverts, conduits and valves. Valves are located in the longitudinal culverts close to the upstream and downstream ends of a chamber, and control water flow. In systems with water saving basins, valves located in the valve block monolith adjacent to the lock walls control water flow to and from the water saving basins. Transverse flow culverts called conduits (to distinguish them from the longitudinal flow culverts) connect the chamber to the basins. The conceptual designers of the Pacific locks filling and emptying system selected a wheel-type, vertical-lift valve, driven by hydraulic cylinders similar to the ones used in the rising stem valves of the Panama Canal locks, as the culvert and conduit valves.

For the Pacific Locks three-lift design, 16 culvert valves and 36 conduit valves would be needed. Details of the operating machinery of the culvert and conduit valves is shown in Appendix D. Table 7.3 shows their estimated required dimensions and weights.

Valves ID	Hydraulic Head (m)	Width (m)	Height (m)	Weight (tons)
Culvert (16 ea.)	25	4.5	7.5	23
Conduit Upper level (12 ea.)	30	5.7	7.5	36
Conduit Middle level (12 ea.)	30	5.7	7.5	36
Conduit Lower level (12 ea.)	50	5.7	7.5	51

Table 7.3. Pacific Locks Culvert and conduit valve estimated dimensions and weights

- **Installation Procedure**

  A basic assumption of this cost estimating/scheduling effort is that both the culvert and conduit valves and their operating equipment (hydraulic cylinders, power units, etc.) would be constructed in an international steel work shop that would have enough capacity to produce the valves in the required timeframe. They would be transported to Panama as single units in a cargo vessel, and unloaded at the materials handling dock constructed for the lock construction project on the southwest bank of the Pacific entrance channel. Once there, they would be loaded on flat bed trailer trucks that would transport them to the construction site.

  When the lockhead (culvert valves) and valve block monolith (conduit valves) civil work are completed (including the installation of all embedded metals, bottom and top seals, vertical guide rails, etc.), the valve body would be lowered into the valve slot by a 60-ton (or 40-ton, if a lesser capacity is required) crane located on top of the lockhead or valve block. Once in the closed position, the valve sealing would be adjusted and the hydraulic cylinder would be positioned with the crane and secured to the concrete slab on top of the valve body. The cylinder rod would be extended and mechanically connected to the valve body. The installation of the hydraulic power units and electrical control panel would be completed in their respective valve rooms. Testing of the equipment should follow.

  The installation of the valves would start with the culvert valves of lockheads 4 and 3, followed successively by the conduit valves in the valve block monolith of chamber 3, the conduit valves in the valve block monolith of chamber 2, the culvert valves of lockheads 2 and 1, and by the conduit valves in the valve block monolith of chamber 1, this being the most critical because of the shorter allotted time. Before the valves' final commissioning, an additional three months are scheduled for tests and installation adjustments.

The time frame scheduled for each valve installation is summarized in Table 7.5.

Valve type	Location	Time available for installation
Culvert (4 ea.)	Lockhead 4	29 months
Culvert (4 ea.)	Lockhead 3	29 months
Culvert (4 ea.)	Lockhead 2	14 months
Culvert (4 ea.)	Lockhead 1	14 months
Conduit (12 ea.)	Valve Block Monolith Chamber 3 Lower level	27 months
Conduit (12 ea.)	Valve Block Monolith Chamber 2 Middle level	17 months
Conduit (12 ea.)	Valve Block Monolith Chamber 1 Upper level	8 months

Table 7.5. Pacific locks culvert and conduit valves locations and time availability for installation

8.3 Electrical Equipment: Lighting, Power and Control

- **Description**
  The locks also require the installation of the following electrical equipment: Lighting (Outdoors and indoors); Switchgears (High and Low voltage), sectionalizing switches, emergency generators, cable feeders, local control panels, remote and local control PLCs, computers, CCTV and UPS and the control fiber optic loop feeders.
  For a complete listing of the required equipment description and quantities see Appendix D.

- **Installation Procedures**
  A basic assumption of this cost estimating/scheduling effort is that an electrical sub-contractor would be tasked with the installation of the electrical equipment and that the equipment would be imported because of its specialized nature.

8.4 Lighting Equipment

The 35 m high mast poles would be installed once the top-of-wall concrete slab is cured. The poles would be positioned on a prefabricated base (part of the concrete slab design) that has embedded the required anchor bolts with the help of a 20-ton crane. With a portable lowering device, the lamp ring would be lowered and the HPS lamps installed.

The chamber floodlights, which would be placed in special recesses specifically designed to keep them away from any possible vessel contact, can be installed once the chamber top-of-wall concrete slab is finished; the gate floodlights, once the rolling gates are in place; and the lighting required for each building, once the construction of the structure allows it. The electrical feeds for every piece of lightning equipment would be connected to a distribution panel located in the gate technical room closest to each.

The time assigned to install the high masts located in the upper level of Chamber 1 is only 8 months. There is ample time for installing the rest of the lighting equipment.

8.5 Electrical Power Equipment

All the switchgears, transformers, sectionalizing switches, and emergency generators would be placed with the help of a 20-ton crane in their respective high voltage rooms, which are located adjacent to the machinery technical rooms. The timeframe for installation of these pieces of equipment would depend on whether the crane can pass through the doors of the completed building, or whether the equipment has to be installed before its roof is built. The minimum critical time allotted for the installation of the equipment mentioned above is 3 months for Technical/HV room 1.

The cable trays, the loop feeders, and the rest of the required electrical wiring, as well as the compressed air piping, run in the electric gallery, which is in the top-of-wall concrete slab. Once this structure is finished, all of this equipment can be installed. A minimum time of 3 months is allotted for this task.

8.6 Electrical Control Equipment

The cable trays and the fiber optic cable loops can also be installed once the electric gallery is built. Control PLCs are located inside the gates and valves local control panels. The PLCs have to be wired (fiber optics cable) and powered (electric cables) along with the installation of the winches or hydraulic power units. Additional control equipment would be installed inside the technical rooms when these structures are finished. For this task the minimum critical allotted time is of 3 months for Technical/HV room 1.

The main computer, PLCs, screens, UPS, fiber optic racks modules, CCTV, and other control equipment, would be installed inside the Central Control building. This building could be wired as soon as it is finished and its equipment installed so that it is ready for remote testing and operation of the machinery. At least 10 months are available for these installations before the first set of rolling gates are remotely tested.

Costs of operating machinery, gates, and valves are shown in Appendix A.

Appendix A - Pacific Cost Estimate Backup

A		CIVIL WORKS						
Section No.	**Pay Item No.**	**ITEM**	**Pay Unit**	**Quantity**	**UNIT PRICE**	**AMOUNT TOTAL (us$)**	**LOCAL CURRENCY (us$Eq)**	**FOREIGN CURRENCY (US$)**
		MOB AND DEMOB - LOCKS	ls	1	82,852,414	82,852,414	65,389,413	17,463,001
		MOB AND DEMOB - ACCESS CHANNEL	ls	1	31,122,599	31,122,599	22,966,752	8,155,847
1		MOBILIZATION AND DEMOBILIZATION	ls	1	113,975,013	113,975,013	88,356,165	25,618,848
		DIVERSION & CARE OF WATER - LOCKS	ls	1	20,130,426	20,130,426	10,446,269	9,684,156
		DIV & CARE OF WATER - ACC CHAN	ls	1	40,495,843	40,495,843	23,420,512	17,075,331
2		DIVERSION AND CARE OF WATER	ls	1	60,626,269	60,626,269	33,866,781	26,759,487
3		DRY EXCAVATION WORK - LOCKS						
	3.1.	Excavate & Haul Overburden	bm^3	5,486,725	3.42	18,762,565	4,379,241	14,383,324
	3.2.	Excavate & Haul Weathered Rock	bm^3	3,883,700	5.43	21,084,710	5,053,190	16,031,520
	3.3.	Excavate & Transport Rock - Mass Exc	bm^3	1,899,472	8.53	16,202,977	3,399,511	12,803,465
	3.4	Excavate & Haul Rock - For Aggregates	bm^3	3,493,283	8.65	30,207,058	5,864,393	24,342,665
	3.5	Excavate and Haul Structural Rock	bm^3	889,000	13.40	11,908,702	3,078,000	8,830,702
		Total Dry Excavation Locks			6	98,166,012	21,774,336	76,391,676
		DRY EXCAVATION WORK - ACCESS CHANNEL						
		Excavate & Haul Overburden	bm^3	11,936,020	4.00	47,738,447	13,806,335	33,932,112
		Excavate & Haul Weathered Rock	bm^3	12,822,270	6.22	79,727,205	24,343,418	55,383,786
		Excavate & Transport Rock - Mass Exc	bm^3	18,519,287	8.11	150,107,467	42,714,778	107,392,688
		Excavate & Haul Rock - For Aggregates	bm^3	4,142,538	7.62	31,583,628	8,167,668	23,415,960
		Excavate and Haul Structural Rock	bm^3	1,837,445	15.10	27,752,115	10,227,742	17,524,373
		Total Dry Excavation Access Channels			7	336,908,861	99,259,942	237,648,920
3		TOTAL DRY EXCAVATION				435,074,873	121,034,277	314,040,596
4		EMBANKMENTS AND FILLS						
	4.1	Common Fills	fm^3	4,571,077	0.67	3,045,873	913,119	2,132,754
	4.2	Granular Fills	fm^3	300,000	8.29	2,488,364	840,924	1,647,440
4		TOTAL EMBANKMENTS AND FILLS				5,534,237	1,754,042	3,780,194
5		PERMANENT SITE WORK - LOCKS						
	5.1	Clearing& grubbing	hct	200	2,454	490,893	490,893	-
	5.2	Roads	km	5	839,686	4,408,351	4,408,351	-
	5.3	Demolitions	m3	3,750	517	1,937,737	1,937,737	-
	5.4	Temporary Relocations	ea	75	1,292	96,887	96,887	-
	5.5	Permanent Relocations	ea	75	2,584	193,774	193,774	-
	5.6	Utilities	ls	1	2,709,481	2,709,481	2,709,481	-
	5.7	Preparation of Disposal Areas	hct	305	6,459	1,970,032	1,970,032	-
	5.8	Restoration of Disposal Areas	hct	305	12,918	3,940,065	3,940,065	-
		TOTAL PERMANENT SITE WORK - LOCKS				15,747,220	15,747,220	-
		PERMANENT SITE WORK - ACCESS CHANNELS						
		Clearing& grubbing	hct	200	2,749	549,786	549,786	-
		Roads	km	2	940,423	1,645,740	1,645,740	-
		Demolitions	m3	1,250	579	723,402	723,402	-
		Temporary Relocations	ea	25	1,447	36,170	36,170	-
		Permanent Relocations	ea	25	2,894	72,340	72,340	-
		Utilities	ls	-	-	-	-	-
		Preparation of Disposal Areas	hct	305	7,234	2,206,376	2,206,376	-
		Restoration of Disposal Areas	hct	305	14,468	4,412,753	4,412,753	-
		TOTAL PERMANENT SITE WORK - ACCESS CHANNELS				9,646,567	9,646,567	-
5		TOTAL PERMANENT SITE WORK				25,393,787	25,393,787	-

6	CAST IN PLACE CONCRETE WORK						
6.1	Cast in Place Approach Walls	m^3	200,108	83.94	16,797,159	9,618,898	7,178,261
6.2	Cast in Place Lock & Gate Chamber Walls	m^3	1,305,506	73.26	95,643,427	54,372,164	41,271,263
6.3	Cast in Place Lock & Gate Chamber Floors	m^3	148,831	77.78	11,576,129	6,932,371	4,643,758
6.4	Cast in Place WSB Walls	m^3	415,016	101.61	42,171,405	27,282,449	14,888,955
6.5	Cast in Place WSB Floors	m^3	232,959	123.11	28,679,829	18,503,212	10,176,617
6.6	Reinforcing steel	ton	141,773	1,990.92	282,258,070	59,788,654	222,469,416
6.7	Straight Forms	m^2	640,217	112.43	71,982,152	42,370,962	29,611,191
6.8	Curved Forms	m^2	81,851	203.11	16,624,447	8,995,870	7,628,578
6,10	Shotcrete	m^3	20,000	165.76	3,315,250	2,044,382	1,270,868
6.11	Lean Concrete	m^3	30,687	163.41	5,014,625	3,025,191	1,989,434
6	TOTAL CAST IN PLACE CONCRETE WORK		-		574,062,494	232,934,153	341,128,341
					-		
7	ROLLER COMPACTED CONCRETE (RCC)				-		
7.1	RCC Approach Walls	m^3	465,225	50.13	23,322,394	12,047,350	11,275,044
					-		
7.2	RCC Lock Walls	m^3	696,330	50.13	34,908,028	18,031,993	16,876,035
					-		
7.4	RCC WSB Floors	m^3	-	-	-	-	-
7	TOTAL ROLLER COMPACTED CONCRETE (RCC)				58,230,422	30,079,343	28,151,079
	TOTAL CIVIL WORKS - LOCKS				854,723,224.02	378,124,776	476,598,448
	TOTAL CIVIL WORKS - ACCESS CHANNEL				418,173,870.65	155,293,773	262,880,097
A	CIVIL WORKS				1,272,897,095	533,418,549	739,478,545

DESCRIPTION	EA	WT/EA TON	TOTAL WT TON
GATE 1 T1	2	1,900	3,800
GATE 2 T2	2	3,000	6,000
GATE 3 T3	2	3,000	6,000
GATE 4 T4	2	3,100	6,200
TOTAL	**8**		**22,000**

Description	Unit	Qty	Rate us$/unit	Amount us$	Price us$/ton	%
GATES						
1 **Manufacture**						
Steel	ton	24,420	916.67	22,385,000		
Chains/Pins & Rollers	ton	2,200	4,500	9,900,000		
Welding Rod	ton	2,750	2,500	6,875,000		
Shop Paint	m2	308,000	55	16,940,000		
Manufacture Labor	mh	990,000	18.5	18,315,000		
Plant & Equipment	days	733.33	15,500	11,366,667		
				85,781,667		
Cost FOB Shop	Ohs + Profit		1.60	137,250,667	6,238.67	63.87
						-
2 **Transport & Handle**						-
Transport to Site	ton	22,000	400	8,800,000		-
Unload/ Store & Handle	ton	22,000	50	1,100,000		-
						-
Transport & Handle				9,900,000	450.00	4.61
						-
3 **Installation**						-
Labor	mh	80,000	25	2,000,000		-
Equipment	hr	4,889	3,200.00	15,644,444		-
Welding Rod	ton	330	2,500.00	825,000		-
Field Paint	m2	308,000	35.33	10,881,640		-
Testing	ls	8	1,485,000.00	11,880,000		-
Misc Supplies	ls	1	1,100,000.00	1,100,000		-
						-
				42,331,084		-
	Ohs + Profit		1.60	67,729,735	3,079	31.52
						-
Cost Manufacturing & Installation				214,880,402	9,767.29	100.00
4 **Operating Machinery**						
Furnish Operating Machinery	ea	8	870,000	6,960,000		
Installation Labor	mh	16,000	25	400,000		
Installation P/E	hr	1,000	250	250,000		
				7,610,000		
	Ohs + Profit		1.45	11,034,500		
Total Furnishing & Installation of Gates				225,914,902		

LABOR	EA	US$/HR	TOTAL
LOCAL	9	7.80	70.20
FOREIGN	1	35.00	35.00
	10	10.52	105.2

Structural Steel Fabrication 3383.3 US$/ton

DESCRIPTION	EA	TONS (EA.)	TONS	INSTALL LABOR MH/EA	INSTALL LABOR US$/EA	INSTALL M&S US$/EA	PURCHASE US$/EA	TOTAL DIR COST US$/EA	TOTAL OH's + FEE US$/EA	TOTAL PRICE US$/EA	TOTAL AMOUNT US$
Gate 1 East Main Culvert Blkhd	4	20	80	700	7,364	500	85,999	93,863	37,545	131,409	525,635
Gate 1 West Main Culvert Blkhd	4	20	80	700	7,364	500	85,999	93,863	37,545	131,409	525,635
TOTAL MAIN CULVERT BULKHEADS	**8**		**160**								**1,051,269**
Chamber 1 North WSB Upper Blkhd	2	33	66	1,100	11,572	825	141,899	154,296	61,718	216,014	432,029
Chamber 1 North WSB Central Blkhd	2	50	100	1,500	15,780	1250	214,998	232,028	92,811	324,840	649,679
Chamber 1 North WSB Lower Blkhd	2	48	96	1,300	13,676	1200	206,398	221,274	88,510	309,784	619,568
TOTAL WSB BULKHEADS	**6**		**262**								**1,701,276**
TOTAL BULKHEADS FOR LOCKS	**14**		**422**								**2,752,546**

LABOR	EA	US$/HR	TOTAL
LOCAL	6	9.50	57.00
FOREIGN	1	40.00	40.00
	7	13.86	97.00

Structural Steel Fabrication 5183.3

DESCRIPTION	EA	TON (EA.)	TONS	INSTALL LABOR MH/EA	INSTALL LABOR US$/EA	INSTALL M&S US$/EA	PURCHASE US$/EA	TOTAL DIR COST US$/EA	TOTAL OH's + FEE US$/EA	TOTAL PRICE US$/EA	TOTAL AMOUNT US$
Gate 1 East Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
Gate 1 West Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
Gate 2 East Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
Gate 2 West Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
Gate 3 East Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
Gat3 3 West Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
Gate 4 East Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
Gate 4 West Main Culvert Valve	2	23	46	400	5,543	2,070	140,299	147,912	66,560	214,473	428,945
TOTAL MAIN CULVERT VALVES	16		368								3,431,560
Chamber 1 North WSB Upper Valve	3	36	108	600	8,314	3,240	219,599	231,153	104,019	335,172	1,005,516
Chamber 1 North WSB Lower Valve	3	51	153	850	11,779	4,590	311,098	327,467	147,360	474,827	1,424,481
Chamber 1 South WSB Upper Valve	3	36	108	600	8,314	3,240	219,599	231,153	104,019	335,172	1,005,516
Chamber 1 South WSB Lower Valve	3	51	153	850	11,779	4,590	311,098	327,467	147,360	474,827	1,424,481
Chamber 2 North WSB Upper Valve	3	36	108	600	8,314	3,240	219,599	231,153	104,019	335,172	1,005,516
Chamber 2 North WSB Lower Valve	3	51	153	850	11,779	4,590	311,098	327,467	147,360	474,827	1,424,481
Chamber 2 South WSB Upper Valve	3	36	108	600	8,314	3,240	219,599	231,153	104,019	335,172	1,005,516
Chamber 2 South WSB Lower Valve	3	51	153	850	11,779	4,590	311,098	327,467	147,360	474,827	1,424,481
Chamber 3 North WSB Upper Valve	3	36	108	600	8,314	3,240	219,599	231,153	104,019	335,172	1,005,516
Chamber 3 North WSB Lower Valve	3	51	153	850	11,779	4,590	311,098	327,467	147,360	474,827	1,424,481
Chamber 3 South WSB Upper Valve	3	36	108	600	8,314	3,240	219,599	231,153	104,019	335,172	1,005,516
Chamber 3 South WSB Lower Valve	3	51	153	850	11,779	4,590	311,098	327,467	147,360	474,827	1,424,481
TOTAL WSB VALVES	36		1566								14,579,981
TOTAL VALVES FOR LOCK	52		1934								18,011,541
Valve Operating Machinery	52			400	5,543	1,000	230,000	236,543	106,444	342,987	17,835,331
											35,846,873

Locks

SUMMARY OF GENERAL ADMINISTRATIVE COSTS & FEES

Cod No.	Description	Un	Qty	mm	Local us$	Foreign us$	Total us$
A	**Personnel**						
	Administrative	ea	32	2,020	1,638,900	6,709,500	8,348,400
	Construction Supervision	ea	94	4,648	3,960,900	18,983,610	22,944,510
	Construction Engineering	ea	51	3,071	1,986,957	6,214,950	8,201,907
	Office/ Accounting & Warehousing	ea	58	3,265	3,098,784	1,386,450	4,485,234
	Purchasing	ea	14	806	504,000	991,800	1,495,800
	Industrial Security & Labor Relations	ea	50	2,736	2,269,350	468,000	2,737,350
	Guards	ea	25	1,469	1,085,568	0	1,085,568
	Maint. Temporary Facilities	ea	29	1,390	1,680,528	0	1,680,528
	Sub-Total Local Personnel	ea	286	15,761			
	Sub-Total Foreign Personnel	ea	67	3,643			
			353	19,404			
A	**Total Personnel**	ea	353	19,404	16,224,987	34,754,310	50,979,297
B	**Total Depr & Operation General P/E**				15,392,431	19,811,028	35,203,459
C	**Construction Temporary Facilities**						
	Temporary Project Access				19,361,974	0	19,361,974
	Plant Instalation				9,428,450	823,420	10,251,870
	Buildings				2,807,240	450,200	3,257,440
	General Utilities				11,401,578	2,229,570	13,631,148
	Worker's Camp				0	0	0
C	**Total Construction of Temporary Facilities**				42,999,242	3,503,190	46,502,433
D	**Total Maintenance of Temporary Facilities**				4,489,171	446,557	4,935,728
E	**Mobilization & Demobilization**						
	Personnel				418,750	1,675,000	2,093,750
	P/E				3,390,568	2,758,944	6,149,512
	Demob. P/E & Personnel				3,809,318	3,196,457	7,005,775
E	**Total Mobilization & Demobilization**				7,618,635	7,630,401	15,249,036
F	**General Services and Supplies**				2,574,076	2,123,016	4,697,092
G	**Taxes**				39,538,108	0	39,538,108
H	**Insurances and Guaranties**				7,200,000	16,500,000	23,700,000
I	**Interest During Construction**				0	0	0
	Total Taxes/Insurances/Guarantees/Interest				46,738,108	16,500,000	63,238,108
	TOTAL OVERHEADS				136,036,651	84,768,502	220,805,153
J	**Home Office**				-	25,000,000	25,000,000
K	**Fees**				-	74,106,698	74,106,698
	Total Home Office Overheads & Fees				-	99,106,698	99,106,698
	TOTAL OVERHEADS & FEES (INCL MOB & DEMOB)				136,036,651	183,875,200	319,911,851

Channel

SUMMARY OF GENERAL ADMINISTRATIVE COSTS & FEES

Cod No.	Description		Un	Qty mm	Local us$	Foreign us$	Total us$
A	**Personnel**						
	Administrative	ea	19	1,213	2,648,700	0	2,648,700
	Construction Supervision	ea	33	1,980	4,023,000	0	4,023,000
	Construction Engineering	ea	30	1,858	2,387,007	0	2,387,007
	Office/ Accounting & Warehousing	ea	22	1,591	1,728,870	0	1,728,870
	Purchasing	ea	9	533	480,600	0	480,600
	Industrial Security & Labor Relations	ea	25	1,422	1,498,950	0	1,498,950
	Guards	ea	24	1,728	1,266,960	0	1,266,960
	Maint. Temporary Facilities	ea	12	590	772,431	0	772,431
	Sub-Total Local Personnel	ea	174	10,915			
	Sub-Total Foreign Personnel	ea	0	0			
			174	10,915			
A	**Total Personnel**	ea	174	10,915	14,806,518	0	14,806,518
B	**Total Depr & Operation General P/E**				4,651,509	7,294,444	11,945,953
C	**Construction Temporary Facilities**						
	Temporary Project Access				3,582,668	0	3,582,668
	Plant Instalation				2,150,000	450,000	2,600,000
	Buildings				849,467	314,717	1,164,183
	General Utilities				3,450,729	1,566,927	5,017,656
	Worker's Camp				0	0	0
C	**Total Construction of Temporary Facilities**				10,032,863	2,331,644	12,364,507
D	**Total Maintenance of Temporary Facilities**				1,108,137	313,585	1,421,723
E	**Mobilization & Demobilization**						
	Personnel				0	0	0
	P/E				2,920,631	2,602,599	5,523,230
	Demob. P/E & Personnel				2,920,631	1,615,855	4,536,486
E	**Total Mobilization & Demobilization**				5,841,262	4,218,454	10,059,716
F	**General Services and Supplies**				1,114,526	0	1,114,526
G	**Taxes**				22,677,365	0	22,677,365
H	**Insurances and Guaranties**				3,600,000	8,775,000	12,375,000
I	**Interest During Construction**				0	0	0
	Total Taxes/Insurances/Guarantees/Interest				26,277,365	8,775,000	35,052,365
	TOTAL OVERHEADS				63,832,181	22,933,128	86,765,308
J	**Home Office**				-	500,000	500,000
K	**Fees**				-	34,873,632	34,873,632
	Total Home Office Overheads & Fees				-	35,373,632	35,373,632
	TOTAL OVERHEADS & FEES (INCL MOB & DEMOB)				63,832,181	58,306,759	122,138,940

Appendix B - Pacific Concrete Amount Backup

The following table 6.1 presents the concrete volumes calculated for each section.

Description	RC + RCC Option	
	RC	RCC
Lock / Gate Chamber Walls	m^3	m^3
Lockhead 1 – Walls	132,585.22	
Lockhead 2 – Walls	175,424.22	
Lockhead 3 – Walls	174,873.98	
Lockhead 4 – Walls	186,874.45	
Lock Chamber 1 – Walls	222,451.85	232,415.39
Lock Chamber 2 – Walls	215,670.00	225,756.18
Lock Chamber 3 – Walls	197,626.42	238,158.65
Subtotal	**1,305,506.13**	**696,330.21**
Lock / Gate Chamber Floor		
Lockhead 1 Floor	23,125.10	
Lockhead 2 Floor	25,496.25	
Lockhead 3 Floor	25,620.00	
Lockhead 4 Floor	25,815.20	
Chamber Floor	48,774.08	
Subtotal	**148,830.63**	
Total Concrete Volume	**1,628,815.82**	**1,101,970.23**

Table 6.1 RC and RCC Concrete Volumes

Table 6.2 summarizes the concrete volumes required for the approach walls.

Description	RC m3	RCC m3	Total m3
Approach Walls	200,108.16	465,224.97	665,333.13

Table 6.2 Concrete volumes for Approach Walls

Description		Cold Joints (mt^2)	Sub - total
Gates	Total HCJ	353,408.40	368,873.87
	Total of VCJ	15,465.47	
Chambers	Total HCJ	178,920.00	200,396.70
	Total of VCJ	21,476.70	
Floors	Total HCJ	81,008.00	86,864.00
	Total of VCJ	5,856.00	
Approach	Total HCJ	69,660.00	75,210.00
	Total of VCJ	5,550.00	
WSB	Total HCJ	15,165.00	19,258.71
	Total of VCJ	4,093.71	

Table 6.3 Summary of Cold Joint Quantities

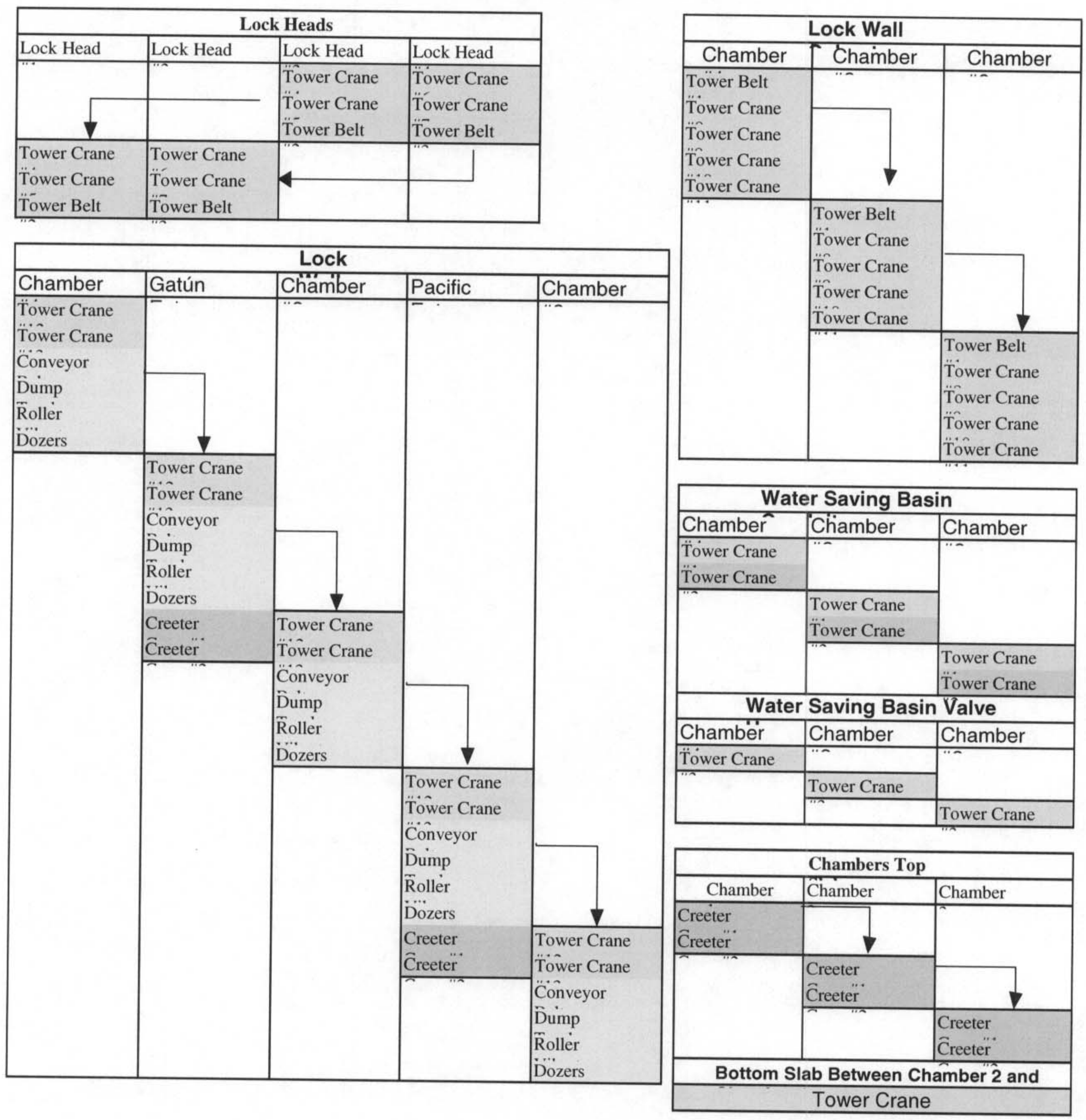
Description	**RC (m^3)**
Volume of Valve Chambers	38,900.40
Volume of Conduits	153,106.20
Volume of Conduits –Crossing	27,410.40
Volume of Intakes	142,012.30
Volume of Walls	53,586.65
Total RC Volume	**415,015.95**

Table 6.4 shows the concrete volume for the elements mentioned.

Description	RC (m^3)	RCC (m^3)
RCC chamber crossing		33,969.15
RCC on surface		106,515.00
WSB floors	92,475.00	
Total Volume of Concrete	**92,475.00**	**140,484.15**
Total RC Volume		**232,959.15**

Table 6.4 Water Saving Basins Concrete Volume – Floors

PACIFIC LOCKS - CONCRETE PLACEMENT EQUIPMENT



Appendix C - Pacific Excavation Backup

Geological Considerations:

Geological formations found along the alignment of the Post Panamax locks and channels are heterogeneous in nature. They consist of three main types of rocks:

- Igneous, predominantly intrusive diabase and basalt, which are present as dikes, flows and laccolith.
- Pyroclastics, mainly bedded tuffaceous agglomerates, locally identified as Pedro Miguel formation
- Sedimentary, identified as La Boca formation and to a lesser extent by the Cucaracha formation.

Basalt is the most prevalent rock type over the southern section of the locks alignment. It is hard, strong, and generally dark-grayish to blackish in color, finely crystallized, and locally porphyritic igneous rock. Its petrography is typical dolerite rock mass with abundant plagioclases and ferromagnesian minerals.

Pedro Miguel formation is made up of volcanic deposits composed of grayish, fine to coarse textured agglomerates cemented in a dense tuffaceous matrix. It contains sub-angular to sub-rounded pieces of dark gray to black colored basalt, which range from 1 cm to 50 cm. When fresh, the Pedro Miguel agglomerate formation is tightly cemented and hard, and its massive unsystematic jointing character sets it apart. This formation is mostly found in the middle area of the alignment channel.

La Boca formation corresponds to sedimentary alternated sequence of dark, medium hard, compact, shale with intercalated medium hard to hard sandstone beds. Prevailing beds of shale are laminated with well-developed schistosity cleavage parallel to the bedding. Sandstones are fine to very coarse grained and intercalated within shale in the form of thin or lenticular beds with cross bedding. It is a medium hard to soft formation, which is prone to weathering. This formation covers most of the east side of the alignment channel, the future locks upper chamber, the Pacific approach wall and part of the Pacific approach channel.

Cucaracha formation is composed of greenish-gray colored clay shale with intercalated thin beds of poorly cemented sandstone. It is exposed around the northern part of the future channel alignment as spots of soft rock mass.

Soil overburden is developed over most of the area as a result of the in-situ weathering of rock formations. These residual soils generally have high clay content. The overburden is also composed of fluvial, torrential and marine alluvium, which constitutes a minor portion of the material involved in the future excavation work. It is composed of layered and saturated organic silts and soft sands. The depth of the overburden varies and may be found deeper than 15 m. In addition to alluvium and residual soils, quantities of artificial fill occupy some low areas along the proposed alignment as a result of old disposed materials from dredging activities and excavations.

Weathering depth varies considerably depending on the rock mass type. La Boca sandstone and shale tend to weather rapidly where exposed and subjected to alternate wetting and drying. Weathering ranges in depth from 3 to 6 m. Cucaracha shale weathers and breaks down rapidly upon exposure to the air.

Weathered Cucaracha material is known to act like bentonitic clay, and when excavated, it may generate slides of mudflow type. Weathering of basalt masses is superficial. It ranges from less than 1 m to 6 m thick. Weathering of Pedro Miguel agglomerates is comparable to basalt.

Appendix D - Pacific Electromechanical Backup

The principal characteristics of the rolling gate equipment are summarized in Table 7.2.

Item	Unit	Quantity per gate	Total	Type
Motors	ea.	2	16	300 kW, Asynchronous, AC, 60 Hz, Variable speed drive, 690 V
Auxiliary Motors	ea.	1	8	30 kW, Asynchronous, AC, 60 Hz, Variable speed drive, 690 V
Gear Box	ea.	1	8	
Secondary Gear Box	ea.	2	16	
Wire rope drums	ea.	2	16	2 m diameter
Steel Cable	ea.	4	32	52 mm diameter
Local Control Panel	ea.	1	8	

Table 7.2. Description of rolling gates operating equipment for the Pacific Locks

The principal characteristics of the valves operating machinery are summarized in Tables 7.4. and 7.5.

Culvert Valves

Item	Unit	Quantity/valve	Total	Type
Hydraulic cylinder	ea.	1	16	Area: 5 dm^2, Volume: 375 l, stroke:7.5 m
Motor	ea.	2	32	35 kW, AC, 60 Hz, 690 V
Hydraulic Power unit	ea.	1	16	70 kW, 100 tons, 200 bars, 187.5 l/min
Local Ctrl. Panel	ea.	1	16	

Table 7.4. Description of culvert valves operating machinery for the Pacific Locks

Conduit Valves

Item	Unit	Quantity/valve	Total	Type
Hydraulic cylinder	ea.	1	36	Area: 5 dm2, Volume: 375 l, stoke:7.5 m
Motor	ea.	2	72	35 kW, AC, 60 Hz, 690 V
Hydraulic Power unit	Ea.	1	36	70 kW, 100 tons, 200 bars, 187.5 l/min
Local Control Panel	ea.	1	36	

Table 7.5. Description of conduit valves operating machinery for the Pacific Locks

The lighting equipment needed for the Pacific Lock is listed in Table 7.6.

Item	Unit	Total	Type
High Mast Lighting Poles	ea.	61	35 m tall, hot dipped galvanized steel
High Mast Lighting Lamps	ea.	480	1000 W, HPS, 100 lux working area illumination
High Mast Lowering device	ea.	2	**(not included)**
Gate floodlights	ea.	32	150 W, metal halide floodlights
Chamber flood lights	ea.	144	150 W, metal halide floodlights
Gate Technical room lights	ea.	180	2, 100 W fluorescent lamps per 10 m^2
Technical room lights	ea.	80	2, 100 W fluorescent lamps per 10 m^2
Maintenance Building lights	ea.	208	2, 100 W fluorescent lamps per 10 m^2
Cable Tray Supports	m	500	
Cross over cable tray	m	210	

Table 7.6. Description of Pacific Locks Lighting Equipment

The electrical power equipment needed for the Pacific Lock is shown in Table 7.7.

Item	Unit	Quantity per HV room	Total	Type
High Voltage Switchgear	ea.	1	2	Metal enclosed cubicle, equipment circuit breakers, 12,000 / 1,200 V
Low Voltage Switchgear	ea.	1	8	Metal enclosed cubicle, air vacuum high voltage circuit breakers
Machinery Transformers	ea.	2	8	800 kVA, 1200 V / 690 V /240V / 120V, delta –star
Standby Transformer	ea.	1	4	800 kVA, 1200 V / 690 V /240V / 120V, delta –star
Track Transformers	ea.	1	8	630 kVA, 1200 V /480 V, delta –delta
Standby Transformer	ea.	1	2	1200 V /480 V, delta –delta
Machinery Transformers	ea.	1	2	400 kVA, 1200 V / 690 V /240V / 120V, delta –star
Standby Transformer	ea.	1	2	1200 V / 690 V /240V / 120V, delta –star
Emergency Diesel Set	ea.	2	2	1600 kVA, 400 V generator with step up transformer 400 / 12,000 V
Sectionalizing Switches	ea.	2	16	15kV, 600 A

Loop Feeders	Unit	Total	Type
HV feeders	m	6000	300 AWG, 12,000 V, single core, Cu or Al, XLPE insulation
LV Loop feeders	m	7500	300 AWG, 1200 V, single core, Cu or Al, XLPE insulation
Low voltage cables	m	ls	12 AWG, Multicore, 3 conductors per cable, Cu or Al,
Low voltage machinery cables	m	1400	2/0, 1kV shielded, single core, Cu or Al, XLPE insulation

Table 7.7. Description of Pacific Locks Electrical Power Equipment

The electrical control equipment needed for the Pacific Lock is presented in Table 7.8.

Item	Unit	Total	Type
PLC	ea.	20	Includes enclosure, power supply, CPU, I/O cards, ethernet & communication cards
PLC displays	ea.	20	
Workstations	ea.	5	inc. 20" display screen with keyboards, mouse
Printers	ea.	3	
Projection Screen	ea.	1	4 m^2
Engineering Station	ea.	1	inc. 20" display screen with keyboards, mouse
Local Control Panels	ea.	20	
CCTV system			
Fiber Optic cables	m	5000	
Fiber Optic cables network equipment	ea.	1	

Table 7.8. Description of Pacific Locks Electrical Control Equipment

Appendix E - Utilities Relocation Backup

Water Utilities:

For cost estimating purposes, it was assumed that approximately 2,650 m. of 0.4-m.φ class 50, M-J'd., cement-lined ductile iron pipe complete with two (2) 0.4-m.φ tees and two (2) 0.4-m.φ R.S. gate valves and approximately 3,200 m. of 0.6-m.φ class 50, M-J'd., cement-lined ductile iron pipe complete with two (2) 0.6-m.φ tees and two (2) 0.6-m.φ R.S. gate valves are laid out in the field in an approximately 2,650 m. long 1.8-m. wide x 1.2-m. deep ditch for both potable water lines and in an approximately 550 m. long 1.2-m. wide x 1.2-m. deep ditch for the 0.6-m.φ line, respectively. Additionally, it was assumed that the whole length of the bottom of both ditches is bedded with non-compacted, 0.15-m. deep, 15/20-mm. crushed stone and mechanically back filled with non-compacted common earth. The total temporary relocation cost for the Pacific side locks water utilities does not include contingencies for any possible unforeseen mechanical accessories or fittings required for completing the installation.

Additionally, it was assumed that nine (9) 0.4-m.φ 90° long radius elbows, two (2) 0.4-m.φ 45° long radius elbows, nine (9) 0.6-m.φ 90° long radius elbows, and two (2) 0.6-m.φ 45° long radius elbows are required to complete the permanent water utilities relocation.

The total water demand is estimated as follows:

Daily Industrial Usage Water Demand

± 0.926000 MGD (R.C. & R.C.C. Concrete Mixing & Joint Prep.)
± 1.141347 MGD (Coarse Aggregate Washing)
± 0.019530 MGD (Drilling and Blasting)
± 2.086877 MGD **Total Estimated Industrial Usage Daily Water Demand**

Daily Human Consumption Water Demand

± 0.190225 MGD (Workers' Drinking and Bathing)
± 0.190225 MGD **Total Estimated Human Consumption Daily Water Demand**

Electric Utilities:

The total electric energy demand is estimated as follows:

100% Average Load Total Electric Energy Demand:

	± 1.20 MVA	(Load Type I-Const. Camp Lighting, A/C, I/M, & Telecom)
+	± 2.00 MVA	(Load Type I-Channel Exc. Site Lighting)
+	± 2.00 MVA	(Load Type I-Const. Site Lighting)
=	±5.20 MVA	**Total Estimated 100% Average Electric Energy Demand**

80% Average Load Total Electric Energy Demand:

	± 5.55 MVA	(Load Type II-Const. & Chnl. Exc. Sites Dewat. Pump Bks.)
+	±12.47 MVA	(Load Type III-Const. Camp Concr. & Aggreg's. Plants)
+	± 2.48 MVA	(Load Type III-Const. Site Concrete Placing)
+	± 3.60 MVA	(Load Type III-Chnl. Exc. & C. Sites & C. Camp Compr'd Air)
=	± 24.10 MVA	**Total Estimated 80% Average Electric Energy Demand**

60% Average Load Total Electric Energy Demand:

± 0.51 MVA	(Load Type IV-Const. Camp Shop Equipment)
± 0.51 MVA	**Total Estimated 60% Average Electric Energy Demand**

ATLANTIC LOCKS

1 Atlantic Locks Background

A great deal of dry excavation work was completed 65 years ago for a narrower, shallower, and shorter lock. Since then, the area was flooded and would need to be dewatered to build the new set of Post-Panamax locks. Some dredging work for a 15m-deep channel north of the excavation has also been completed. The northernmost segment of the existing excavation has depths up to 15 meters. The east bank of the existing excavation site has to be widened by approximately 30 meters and the whole excavation needs deepening to the required new lock bottom elevations.

This lock is located about 1500 meters from the existing Gatun Locks, 17 km from Colon City, and about 40 Km by launch or 70 Km car on a two-lane highway from the Pacific Locks.

There are several buildings and houses that could be fitted as field offices and temporary housing for foreign construction technicians. Two-half million gallons capacity elevated potable water tanks with 18" diameter cast iron piping distribution lines serve the town of Gatun. Electric, sewage, and telephone utilities are also available. If an alternate route is not in operation, the contractor would have to schedule all work so that there would un- interrupted access to the existing lock and communities located west of the construction site. The relocation of the utilities would have to be done in without interruption of the service.

The main contractor must consider innovative construction technology and well planned construction material acquisition strategies, taking advantage of economies of scale and foreign (and local) government incentives to perform work on time and under budget if possible. Some other construction issues are described in the attached "Assumptions" list.

The ACP owns and operates all of the construction areas and infrastructure; hence, excavation clearance and construction permits have to be coordinated through it making use of its corporate administrative structure.

2 Atlantic Locks Assumptions

Assumptions made during the development of the cost estimates and schedules for Atlantic Concept Level Designs for the Post-Panamax locks are:

- There is an alternate route for traffic requiring access to the west bank of the existing canal.

- The Davis town site would be available for use by the contractor for offices and staging area.

3 Required Land Acquisitions

On the Atlantic side, a real estate acquisition would be necessary for construction of the triple lift lock configuration. The contractor would need this land as a staging area. Given the proximity of Davis to the construction area, the purchase of the properties in Davis that are close to the locks (see appendix A) would also help to avoid complaints due to noise and construction related nuisances. Since Davis is not within Canal compatibility areas, this land would have to be bought from ARI or its private owners. We estimate that 600,862 m^2 of land would have to be acquired. According to Panama's General Controller's Office, the cost of land in the Gatun area (ID 10000-080, lot 1) is twenty nine dollars per square meter (US$ 29.00/m^2). Using this price as reference, the total cost of acquisition would be US$ 17,423,800.

4 Atlantic Locks Schedule

The total time estimated for the Atlantic locks construction is six years. The major work items that may have an impact on the schedule are the excavation, the concrete, and the electro-mechanical work. The mobilization for excavation and the concrete work begin upon the awarding of the contract.

During the excavation mobilization phase some work at the site may begin if the main contractor subcontracts the work to local contractors. An alternative solution would be for the ACP to contract the items separately, removing them from the main contract. There is the need for road relocations and repairs, construction of a railroad track extension to receive aggregate and crushed stone from the Pacific, reinforcement of the northern and southern plugs for heavy traffic, dewatering of the 1939 excavation site, preparation of the areas for the crushing and batching plants, and clearance of the areas for the heavy equipment platform and shops.

It is assumed that the earliest the contractor can start excavation at the site is six months into the mobilization. At this point it may be possible for the contractor to have his excavation equipment operational.

Excavation would begin at the lower chamber and proceed upstream. After the upper chamber and the upper approach are excavated in the dry, the lower approach would be excavated. The total estimated time for excavation at the locks is 40 months.

Approximately 650 m of the upper approach is to be constructed in the wet on piles. Mobilization for the marine construction begins 24 months after the contract starting date and continues for 12 months. The construction of the pile-supported section of the approach wall would begin 36 months after the contract begins and last for 18 months. This portion of the work may be subcontracted, since it requires special barge mounted equipment that would not be utilized for any other aspect of the job.

The plants (re-screening, RC and RCC, ice, pre-cooling, etc.) would arrive for assembly and testing one year into mobilization and concrete work would begin six months later. Concrete work would begin in the lower chamber and proceed towards the upper chamber maintaining a minimum distance of 200m behind the excavation. For the purpose of equipment use, the work would be divided into miter gate recess, lock walls, water saving basin conduits, and water saving basins

The equipment used for each of these activities in the lower chamber would be used successively in the middle and upper chambers. The estimated time for completion of the concrete work is 52 months.

The estimate assumes that the gates, valves, and bulkheads would be designed, fabricated and transported to the site under a separate contract. The electro-mechanical installation work could begin when civil work is completed in any given chamber. The installation time for the main culvert valves varies between 28 months for recess no. 3 valves and 6 months for upper valves. The installation time for water saving basin valves varies between 30 months for the lower chamber and 14 months for the upper chamber. The times for the valve installation are based on the availability of the concrete work for installation of the electro-mechanical equipment. The float time is reduced for each successive chamber, with the installation in the upper chamber being critical. All concrete work must be completed and the valves (main culvert and water saving basins) must be installed before installing the gates.

The installation of the gates requires flooding of the chambers and that the Atlantic high tide reaches the upper chamber. All work on the chamber bottom must be complete by then. Sea gates (gates in the lower chamber) could be installed at ocean water levels. The installation of the gates in the middle chamber and in the upper chamber requires that the lower gates be closed and able to retain water. At this time, water would be siphoned into the chambers until the depth required for the installation of the gates is achieved. A floating crane with capacity to support the buoyant weight of the gates is required for the installation. The estimated time for the installation of the gates would be one month per recess. A two-month testing period would be scheduled after the completion of all gate installations.

5 Atlantic Locks Constructibility Assessment

In assessing the constructibility of the Atlantic locks, the cost team determined that the construction of the design proposed by the United States Army Corps of Engineers could be built after some modifications. The lock walls are designed as RCC structures but due to the difficulty of the placement caused by the water saving basin conduits crossing through over 50% of the length of the walls on the west side, it was assumed that conventional reinforced concrete would be used instead of RCC.

Another factor that affects the construction of the Atlantic locks is the presence of the longitudinal culverts below the level of the lock floor. The size of the culverts in the lock floor makes placing tower cranes and tower belts difficult. There are alternatives that permit the use of the equipment, such as excavating the culverts after the equipment is removed, reinforcing the sides of the excavation to allow placement of the equipment, or excavating and backfilling the excavation. The last option requires the removal of the filling material before culverts can be constructed.

The estimate is based on USACE's design of the Atlantic lock although Tier 3 results recommended the CPP design. Based on this, the following have been identified as issues to be resolved:

- Design of the Atlantic locks along the lines of the CPP design
- Discharge from the approach channel through the outlets
- Location of the lock in the A1 alignment north of the location proposed by USACE to avoid construction in the wet
- Construction of the spur line from the PCRC line to the lock site
- Water treatment plant for the lock complex
- Design of roads between existing Gatun Locks and the new Post Panamax Locks
- Environmental Mitigation
- Disposal sites

The first and main challenge in this project would be the construction of the southern end of the upper chamber. This section is close to the Gatun Lake bank that has a summit elevation of 26m above mean sea level. A temporary cofferdam might be required to hold lake water while this section of the lock is under construction. Once the double set of lake gates is properly installed and tested, the cofferdam would have to be removed and completion of the south approach wall, including dredging of the entrance channel, (6 additional meters deepening) performed.

6 Relocation of Existing Infrastructure

6.1 Water Utilities

- **Water Utilities Relocation Cost Estimate Assumptions**

The total estimate:

a. Does not include cost of transportation, insurance, freight of materials from the place of manufacture to Panama, and Panama taxes, but does include overhead and profit.

b. Envisions conceptual water utilities relocation basic design coordinated with the Electrical and Aqueducts Division Aqueducts Branch.

- **Temporary Relocation**

Neither the existing ACP 0.3-m.φ potable waterline nor the 0.2-m.φ sewage line require temporary relocation. Both lines would remain operational crossing through the existing 1939's lock excavation site's north plug during the civil work period for the new third set of locks.

- **Permanent Relocation**

The permanent water utilities relocation distance is estimated at approximately 1.0 Km for the 0.3-m. potable water line and 1.7 Km for the 0.2-m. sewage line.

The potable water utilities permanent relocation would be performed by installing new permanent potable water piping through the new set of locks' water utilities cross-under. The cost per meter for the permanent relocation of the potable water utilities was assumed at approximately twice the cost per meter for a standard installation. .

The sewage water utilities permanent relocation would be performed by extending the line to the north with the installation of approximately 1.7 Km of new permanent sewage water piping. Standard installation cost per meter was assumed for the cost per meter of the permanent relocation of the sewage water utilities.

The total permanent relocation cost for the Atlantic side locks water utilities does not include contingencies for unavailable mechanical accessories or fittings required for completing the installation.

- **Water Requirements**

Total Estimated Daily Water Demand for Atlantic Side Locks

± 2.086877 MGD Total Estimated Daily Industrial Usage Water Demand
± 0.190225 MGD Total Estimated Daily Human Consumption Water Demand
± 2.277102 MGD Total Estimated Daily Water Demand

Refer to Appendix D for backup information

6.2 Electrical Utilities

- **Electric Utilities Relocation Cost Estimate Assumptions**

The total estimate:

a. Includes cost of transportation, insurance, freight of materials from the place of manufacture to Panama, overhead and profit, but no Panama taxes.

b. Envisions conceptual electric utilities relocation basic design coordinated with the Electrical and Aqueducts Division Power Generating Branch. This design does not include the requirement of an additional substation.

- **Temporary Relocation**

Both existing ACP 44-KV circuits (Line 403 & 404) and the telecommunications circuits must be relocated to an approximately 3.0-Km long loop around the existing 1939's lock excavation site's north plug during the civil works construction period for the new third set of locks. When civil works are completed, both electric power circuits and the telecommunications circuits would be permanently relocated through the new locks' electric utilities cross-under. The temporary relocation of all the circuits would be done above ground on wooden or concrete poles with the capacity and dimensions required to safely uphold the electric circuits' weight and load.

For cost estimating purposes, it was assumed that two (2) reinforced sets of poles shall carry one (1) 44-KV circuit per set and that one (1) of these reinforced sets of poles shall also carry the telecommunications circuits. The total temporary relocation cost for the Atlantic side locks electric utilities includes telecommunications circuits and possible unforeseen electric equipment contingencies.

- **Permanent Relocation**

The permanent electric utilities relocation distance is estimated at approximately 0.75 Km. The permanent relocation is to be performed by installing new permanent wiring through the new set of locks' electric utilities cross-under. The cost is estimated at approximately four times the cost per meter of the temporary relocation. The total permanent relocation cost for the Atlantic side locks electric utilities includes contingencies for telecommunications circuits and for possible unforeseen circumstances like new switchgear and accessories required for providing the service.

- **Electric Energy Requirements**

Total Estimated Electric Energy Demand for Atlantic Side Locks:

	± 3.20 MVA	Total Estimated 100% Average Electric Energy Demand
+	±14.72 MVA	Total Estimated 80% Average Electric Energy Demand
+	± 0.47 MVA	Total Estimated 60% Average Electric Energy Demand
=	±18.39 MVA	Total Estimated Electric Energy Demand

Refer to Appendix E for backup information

7 Excavation

7.1 Basic Assumptions for the Excavation work

The excavation would start from the north (Atlantic Ocean end) in gate bay 4 and progress southward to reach the gate bay 1 at Gatun Lake.

The excavation for the lock chambers and water saving basins would be done in dry after dewatering the existing trenches of the 1939 excavation. Conventional earth moving equipment would be used for the overburden and Atlantic Muck excavation. The rock (Gatun Formation) is rippable. Drilling and blasting would be necessary if a faster production is required on narrow ledges adjacent the old excavations or to achieve minimal over-excavation in areas to receive concrete.

Both entrances to the new locks (from the Atlantic Ocean and from Gatun Lake) would require wet excavation using cutter suction dredges. Part of the dry excavation material from the locks should be transported by road to the designated disposal site located about 5 km to the north.

For the purpose of this cost estimate the excavated material is not considered suitable for use as aggregate for concrete or as construction material for other parts of the project and all of it would be spoiled in the designated disposal areas.

Table 7.1 shows the total volume material in bank cubic meters to be excavated at the Atlantic site.

Material	Locks	WSB	Total Dry Excavation	Channel (Dredging)
Overburden	6,261,500	512,400	6,773,900	5,938,000
Rippable Rock	8,158,000	2,030,000	10,188,000	3,543,000
Blasted Rock				
Total	**14,419,500**	**2,542,400**	**16,961,600**	**9,481,000**

Table 7.1 Excavation Volumes

7.2 Haul and Access Roads

The main access to the site would be from the City of Colon through the Bolivar Highway. An alternate access is by railway from Panama City. The actual route of the Panama Canal Railway Company that connects Panama City and Colon passes just to the east of the new locks alignment.

From the main access road the contractor would have to rehabilitate existing roads and build new roads for access to the construction areas and to haul in the necessary equipment and materials. To access the project from the east side it is necessary to rehabilitate about 1 km of the existing road and build about 2 km of new road parallel to the locks alignment. An existing road that crosses over the north plug would be used to access the west side of the alignment.

It is assumed that aggregate materials for concrete would come from the Pacific locks excavations and would be transported to the site by train. To accomplish this, it is necessary to rehabilitate the old railway line that crosses over the south plug and goes to the town of Gatun. The aggregate processing plant and concrete batching plant can be located at the southwest end of the alignment near Gatun Lake.

A construction haul road would also be required in order to transport the excavated material from the lock site to the disposal area. This haul road of about 5 km long would travel on the western side of the cut; go across the northern plug, and head north to the designated disposal area.

8 Locks Structure

8.1 Special Construction

According to USACE's design, about 70% of the south (Gatun Lake) approach wall needs to be built in the wet. Gatun Lake has an average depth of 20m in that area and the final depth required is 18m. Installation of 69-2.5m diameter steel caissons with 2" wall thickness, a reinforcing cage with 26 bundles of 4-#18 (57 mm diameter each) reinforcing bars filled with tremie concrete to support a 5m thick reinforced concrete slab is a challenging job. A cofferdam or an earthen plug to protect Gatun Lake while constructing the new lock is also a risky temporary work task.

8.2 Concrete Volume

Concrete volumes were calculated by multiplying the respective section cross-sectional area by its effective length. This indicates that the volume to account for the electrical and operational galleries, the gate machinery recess, the valve rooms, and the culverts must be subtracted.

- **Lock walls**

  USACE submitted a conceptual design for the Atlantic Post Panamax locks that consists of the following elements: three locks chambers 424.7 m in length, two water saving basins per lift, four gate bays, miter gate system for the gate bays, and approach walls at the upper and lower levels. The design includes three types of concrete: reinforced concrete (RC), roller compacted concrete (RCC), and tremie concrete (only used for the caissons at the southern approach wall). For this cost estimate the lock structure was divided into approach walls, gate bays, lock walls, valve buildings, water saving basins and floors.

  The gate bay monoliths were designed as gravity RC structures. There are four gate bays, each with a monolith on both east and west walls.

  The lock walls were designed for a combination of RC and RCC. Figure 5.1 shows that the outer layer of the structure is RC, while the rest is RCC. A one-meter layer is assumed for the calculation of the RC concrete volume. The top wall was designed for RC.

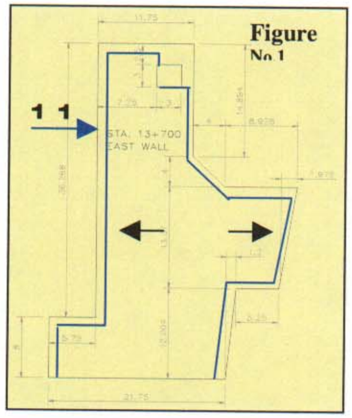
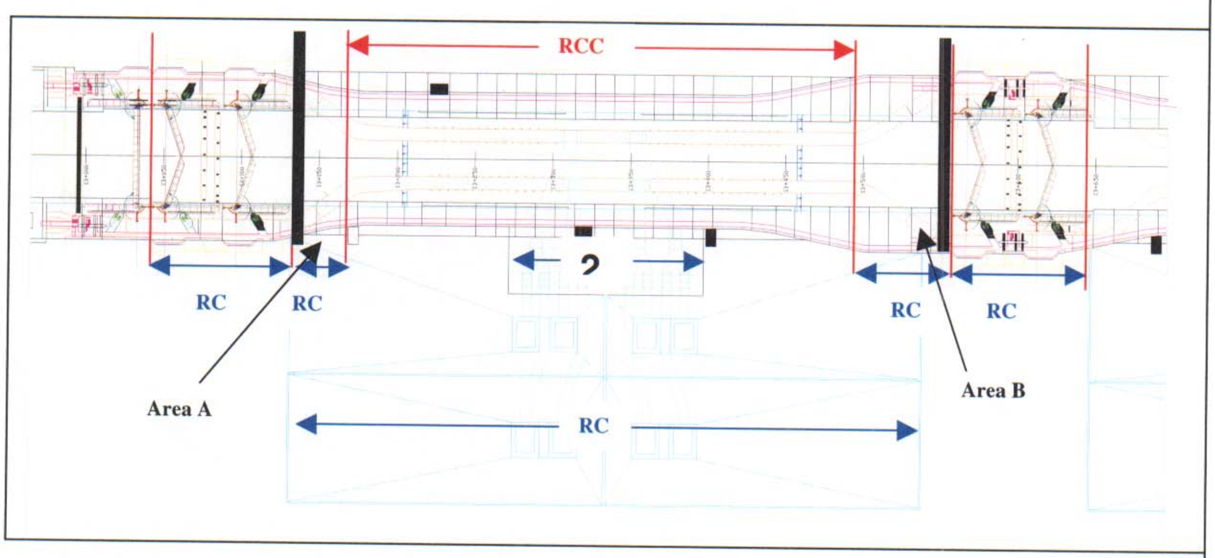


Figure 5.1

The areas where the culverts cross through the lower part of the lock walls, at the beginning and the end of lock walls (close to the gate bays) and in the west side over 50% of the length of the wall (from the water saving through the channel floor), due to the difficulty of the placement, it was assumed that instead of RCC conventional reinforced concrete would be used.

The valve building and water saving basins are located on the west side of the chambers - these elements were designed for RC. The concrete quantity for the valve building was included in the concrete quantity for the Lock Chamber Wall.

The following figure shows the places where RC and RCC are used.



	RC (m^3)	RCC (m^3)	Totals (m^3)
Approach Walls	116,322	611,089	727,411
Lock/Gate Chamber Walls	1,958,551	985,402	2,943,952
Lock/Gate Chamber Floors	315,446	-	315,446
Water Saving Basins Walls	12,246	-	12,246
Water Saving Basins Floors and conduits	183,397	-	183,397
	2,585,962	**1,596,491**	**4,182,452**

- **Manufactured aggregate**

The contractor for the access channel on the Pacific site is responsible for excavation of the basalt that would be used to produce aggregates for the Atlantic Locks.

To obtain the aggregates for the Atlantic site, the contractor for the access channel in the Pacific needs to have the follows: Scalper Plant (150 tph), Coarse Aggregate Crushing and Screening Plant (1000 tph), Sand Plant (400 tph). The calculation of the unit cost for aggregate obtained from the Pacific channel includes plants, labor, material and services and the equipment necessary to process the volume of aggregate and transport the aggregates from the aggregate plant to the railroad on the Pacific site. The unit cost for aggregates on the Pacific site was 2.63 $/ton.

The Panama Railroad would be used to transport aggregates from the Pacific to the Atlantic locks, and the unit price for this transportation is $4.45/m3 (1.65 $/ton).

The cost of aggregate on the Atlantic site is the same as the cost of aggregate on the Pacific site plus railway transportation from the Pacific to the Atlantic. Cost of aggregate = (2.63 + 1.65) $/ton = 4.28 $/ton.

It was only necessary to consider the transfer of aggregate by railroad, the re-screening plant and the 24" conveyor belt (1000 feet) to calculate the additional cost of aggregate on the Atlantic site.

Aggregate is received at a railroad aggregate transfer station, which includes a 24" conveyor belt to send it to the transfer pile and the Re-Screening Plant.

The aggregate is transferred from the Re-Screening plant to the Batch plant using a 24" conveyor belt (1000 feet). Because the distance between the Re-Screening plant and the Batch plant is almost 600 meters, it is necessary to have two conveyor belts to transfer the aggregate.

- **Formwork**

The amount of formwork was calculated from the concrete form contact areas determined for these main sections: gate bays, lock walls (which are subdivided into Sections A and B), valve building, water saving basins, and water saving basin conduits.

The amount of formwork for the lock walls was calculated based on a scheme of construction that considers that RCC (roller compacted concrete) would be placed simultaneously with the RC (reinforced concrete) face of the chamber wall. Because of this construction method, forms would only be required for the outer face of the chamber walls.

Several types of forms must be used to account for the wide range of shapes and construction schemes encountered in this project.

The operating and electrical galleries are located within the lock walls and can be pre-cast, thus reducing the formwork requirements and accelerating the work.

Transformer rooms and bulkhead and valve slots are located inside the valve building. The contact areas for these forms were included in the concrete form quantities of the valve building.
Additional form is need in the gate bays for the gate machinery recess and machinery room, operating and electrical gallery, the valve room and machinery room, bulkhead slots and the culvert.

The blue lines in Figure **5.2** show the areas where concrete forms are required. The entire area of the chamber face requires concrete forms, while on the back; only the upper part needs them. Concrete on the lower part of the back of the wall is placed against the rock, and, therefore, there is no need for concrete forms in this area.

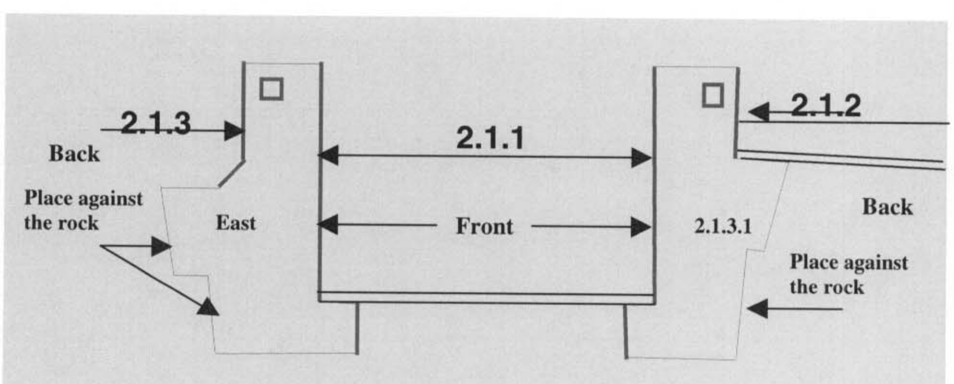


Figure 5.2 Main concrete areas that would require formwork

The types of forms to be used on each part of the locks and the number of form reuses were determined in order to compute the total square meters of fabricated forms required. This number is obtained by dividing square meters of contact area into the number of reuses for each different type of form.

Tables 5.1, 5.2 and 5.3 below show assumptions for reuse of each type of form, the type of concrete forms used in the different areas of the locks, and a summary of the concrete form results.

Type of concrete form	Reuse
Cantilever Forms - Wood	4
Soffit Forms – Steel	30
Cantilever Steel Forms - Metal	30
Cantilever Gang Forms - Metal	30
Curve forms for conduits	12
Pre-cast	30
WS Culvert form	

Table 5.1. Number of form reuses per type of form

Areas	Type of Concrete Form
Chambers	
Front wall	Cantilever Gang Forms
Back wall	Cantilever Gang Forms
Valve building	Cantilever Steel Forms – Metal
Valve Building (Soffit)	Soffit Forms – Steel
Operating gallery (pre-cast)	Precast
Electrical gallery (pre-cast)	Precast
Bulkhead slot	Cantilever Forms - Wood
Valve access	Cantilever Forms - Wood
Transformer room	Cantilever Forms - Wood
Soffit Transformer room (soffit)	Soffit Forms – Steel
Culvert	Curve forms for culvert
WSB	
Walls	Cantilever Steel Forms – Metal
Conduits	WS Culvert form
Gate Bays	
Front wall	Cantilever Steel Forms
Back wall	Cantilever Steel Forms

Gate machinery recess & machinery room, operating gallery	Cantilever Forms - Wood
Soffit (Gate machinery recess & machinery room, operating gallery)	Soffit Forms – Steel
Valve room and machinery room	Cantilever Forms - Wood
Soffit Valve room and machinery room	Soffit Forms – Steel
Service valve access	Cantilever Forms - Wood
Bulkhead slot	Cantilever Forms - Wood
Electrical gallery (pre-cast)	Precast
Transformer room	Cantilever Forms - Wood
Transformer room (soffit)	Soffit Forms – Steel
Culvert	Cantilever Steel Forms – Metal
Soffit Culvert	Soffit Forms – Steel

Table 5.2. Type of form needed depending on construction area

Type of concrete form Summary	Reuse	Contact Area m2	Fabr/Buy m2
Cantilever Forms - Wood	4	67,433	16,858
Soffit Forms - Steel	30	61,740	2,058
Cantilever Steel Forms - Metal	30	264,665	8,822
Cantilever Gang Forms - Metal	30	131,401	4,380
Curve forms for conduits	12	12,960	1,080
Precast	30	49,131	1,638
Curve Forms - Wood	1	27,551	27,551
Form over the rock	1	3,138	3,138
Total square meters		**618,018**	**65,524**

Table 5.3. Summary of formwork requirements

9 Steel Reinforcement

The USACE design uses reinforcing steel (kg/m) in ~~the~~ different areas of the new locks. With that information they calculated the total kilograms of steel needed for the locks.

Using USACE amounts we calculated a reinforcing steel/concrete ratio (kg of steel/m3 of concrete), which was applied to the concrete amounts for this project to determine the reinforcing steel needed per area.

Part of the locks	Ratio (kg/m3) from USACE study
Approach Wall	0.82%
Lock Walls	0.59%
Gate bay	0.99%
Floors	3.62%

Table 7.1. Reinforcing steel ratios per lock areas

USACE's design detailed enough to allow the calculation of the reinforcing steel for water saving basins and caissons for the south approach wall.

Aplying the ratios to the concrete quantities the results are:

	Reinforce bars (tons)
Approach Wall	9,586
Lock Walls	12,988
Gate bay	7,213
Floors	9,091
WSB	13,894
Total	**52,772**

Table 7.2. Reinforcing steel requirements (tons) per lock areas

10 Concrete Placing Methods

- **Transversal Conduits**

Concrete placing would begin 12 months after the beginning of excavations; by then, Chamber 1 excavation would be completed. Concrete would first be placed for the conduits that cross from the Water Saving Basins (WSB) to Chamber 1. This concrete work would require two (2) 150 ton - Truck Cranes and one Tower Crane. The same equipment would be used for the conduits in Chamber 2 and Chamber 3.

- **Gate Bays**

Gate bays and the adjacent portion of the lock wall that that have the culverts diverted through them are considered as one element in the gate bay construction schedule. The schedule shows that work on Gate Bay 2 would start after the excavation of Chamber 2 is 50 % completed. Two (2) tower cranes and one (1) 24" tower belt would be used for this job. The tower cranes would handle rebar and forms; while would be used to place the concrete. Concrete

placement on the Gate Bay 3 structure would begin six months after excavation on Chamber 3 is 50% completed. By then work on Gate Bay 2 would not be completed, therefore another set of equipment would be needed.
After completion of the Gate Bay 2 structure, the equipment would be transferred to Gate Bay 1.Two months are allowed in the schedule for such transfer. ------ By then, Gate Bay 3 would be complete and the equipment would be transferred to Gate Bay 4; again, 2 months are allowed for this transfer.

- **Valve Buildings**

Construction of Valve Building 3 would start immediately after the Transversal Conduits of Chamber 1 are completed. One tower crane would be used to build the Valve Building 3, afterwards the equipment would be transferred for construction of Valve Building 2.; and afterwards it would be transferred for the construction of Valve Building 1.

- **Water Saving Basins**
  Construction of Chamber 3 of the WSB would start immediately after the Transversal Conduits are built. Construction of Chamber 3 of the WSB would be performed using one (1) tower crane and one 8"concrete pump. The same equipment would be used to build Chamber 2 and Chamber 1 of the WSB. The construction time would be the same on each Chamber of the WSB

- **Lock Walls**

Construction time for the Lock Walls includes placements for both the conventional reinforced concrete and the roller compacted concrete. The equipment used for the conventional concrete placement includes four (4) tower cranes and one (1) 24" tower belt. The tower cranes would handle rebar and forms and would sometimes be used to place RC. The 24" tower belt would be used to place conventional concrete. The roller compacted concrete would be transported from the RCC plant to a transfer hopper using a 24" conveyor belt. RCC would be discharged from the transfer hopper to 35-ton off-highway end-dump trucks. Dump trucks would haul and end dump RCC in the placement area; afterwards RCC would be spread in 30cm layers using bulldozers and then rolled using vibrating rollers. The work begins on Chamber 3 lock walls, and when finished the same equipment would be transferred to Chamber 2, where the same concrete placing methods would be use. Afterwards, the equipment would be transferred to the Atlantic Approach Wall. After the approach wall is built, the equipment would be transferred to Chamber 1 and would finally be transferred to the Gatun Approach Wall. Every transfer time would be one month from one site to another.

- **Top Slab on Walls**

The lock walls described above do not include the top slabs. Before starting the construction of the top slab, the lock walls must be completed. Two (2) Creeter Cranes would be used for placement of concrete on the top slab. The same equipment would be used for the three chambers

- **Floor Culverts**

Construction of the floor would start following completion of Chamber top slab. Chamber 3 and 2 floors would start at the same time. To build the culverts in Chamber 2, two (2) truck cranes would be used. Simultaneously the floor in Chamber 2 would be placed with one tower crane. The equipment that would be used on Chamber 3 includes two tower cranes for the floor and longitudinal culverts. And finally Chamber 1 would use the two tower cranes for the floor and longitudinal culverts.

Electromechanical Equipment

10.1 Descriptions and Installation Procedures

10.1.1 Miter Gates

- **Description**

Miter gates are two-leaf steel structures that form a three-point arch to seal the chamber and hold the water. The two leaves are symmetrical regarding the centerline of the lock, and rotate on vertical axes. The pivot of each gate is a pintle ball located at the bottom of the chamber near the lock wall. Each miter gate is driven by a hydraulic cylinder and has a recess area parallel to the lock wall to which the gate recedes when opened (see figure 8.1).

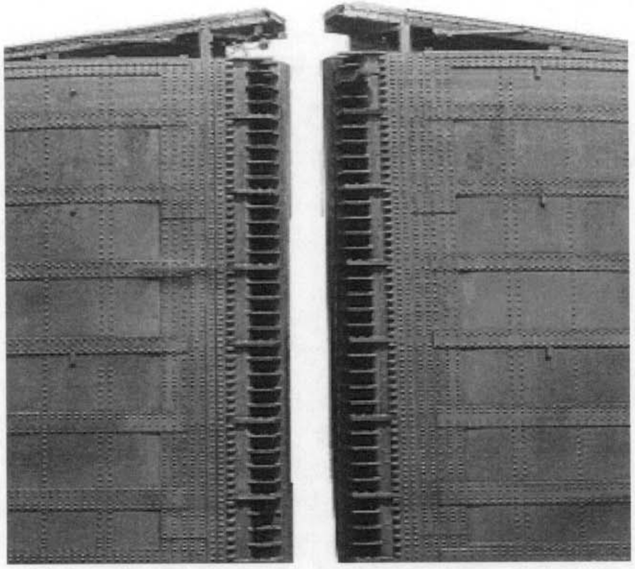


Figure 8.1. Miter gates in the Panama Canal lock

Miter gates are the most common type of gate used for maritime and inland waterways for Panamax- and smaller-size locks. Larger gates have been built and operated satisfactorily over the years. There is one known Post-Panamax lock system using miter gates: It is located in the lock entrance to the Royal Portbury Dock (Bristol, England), where the lock is 42.7 m wide and the gates are 24.5m long x 18.13m high x 3.05m wide.

For the Atlantic Locks three-lift design, 8 pairs of miter gates (16 total) would be needed. Table 8.1 shows their estimated required dimensions and weights:

Gate ID	Length (m)	Width (m)	Height (m)	Weight (tons)
GB1 (4 ea.)	35.5	4.5	22.3	4831
GB2 (4 ea.)	35.5	4.5	30.4	5896
GB3 (4 ea.)	35.5	4.5	30.4	5896
GB4 (4 ea.)	35.5	4.5	30.4	5896

Table 8.1. Miter gates estimated dimensions and weights for the Atlantic Locks

As mentioned before, the miter gate machinery would be the direct connection hydraulic cylinder type, similar to those being used in the existing locks. A gimbal assembly would support the cylinder in the miter gate machinery recess and the piston rod would be connected to the gate by a clevis. Greaseless bushings would be used and the miter gate cylinders would be identical at all locations to minimize spare part requirement. Each cylinder would have a 711 mm bore, 508 mm rod, and 10,491 mm stroke. A separate hydraulic power unit would be provided for each gate. The hydraulic system would have a design pressure of 17.2 MPa and each power unit would have a 56 KW motor (see figure 8.2).

Figure 8.2. Hydraulic Cylinder

The direct connection machinery is very common in Europe and is becoming common in the United States. The gate pivots on a pintle ball located near the base of the lock wall and is connected at its upper end by a gudgeon pin. The operating machinery provides smooth, reliable, and controlled movement.

Its main characteristics are summarized in Table 8.2.

Item	Unit	Quantity/gate	Total	Type
Hydraulic cylinder	ea.	1	16	711 mm bore, 508 mm rod, 10.49 m stroke
Motor	ea.	2	32	56 kW, 3 ph., 1800 rpm, AC, 60 Hz, 480 V
Hydraulic Power unit	ea.	1	16	1800 l reservoir, design pressure 17.2 Mpa, 24.1 Mpa peak pressure
Local Control Panel	ea.	1	16	

Table 8.2. Miter gates Operating equipment description for the Atlantic Locks

- **Installation Procedure**
  A basic assumption of this cost estimating / scheduling effort is that the miter gates would be constructed at an international steelwork yard that would have enough capacity to produce the gates in the required timeframe. They would be transported to Panama as a single unit either in a submersible type cargo vessel or floated horizontally and towed by tugs.

  Once in Panama's Atlantic side, they would be moored in the new locks entrance channel until the locks are built (including installation of all culvert and conduit valves) and ready for their initial downstream flooding.

It is assumed that by that time, the operating gallery, which would house the operating equipment, would be completed. With the assistance of a 40-ton crane, the hydraulic cylinder and power units, piping and electrical control panels would be lowered into the gallery and placed in position. They would later be electrically and mechanically installed and kept ready for testing when the gate and hydraulic cylinder are connected. With the Atlantic locks flooded to sea level and the Atlantic side cofferdam removed, all 16 gates would be moved to the lower level of the locks and secured. The first gates to be installed would be the GB4 sets. With a proper high tide, each gate would be lifted to a vertical position by a floating crane like the Titan (or larger) and then placed on top of the pintle ball. With the miter gate leaf at a properly close distance to the wall, the hydraulic cylinder rod would be extended and mechanically connected to the gates anchoring slot. A two-month time frame is scheduled for the installation of these two sets of gates.

Even at high tide, water level is not high enough to allow proper flotation of gates GB3, GB2 and GB1 into their recesses. In order to start the upstream flooding to float in gates GB3, GB2 and GB1, at least one of the gates from set GB4 should be operational to allow closing it to hold the additional water that would be siphoned into the chambers from Gatun Lake. When the proper water level is reached, the same procedure would be repeated to install sets GB3, GB2 and GB1. After the required upstream flooding occurs, two months would also be scheduled for the installation of the other six sets of gates. Additionally, two months ~~are~~ would be scheduled for the necessary testing and finishing touches of the installation before the gates' final commissioning.

10.1.2 Culvert and Conduit Valves

- **Description**

  The components of a lock Filling and Emptying system are the culverts, conduits and valves. Valves, located close to the upstream and downstream ends of a chamber, are located inside the longitudinal culverts and control water flow. In systems with water saving basins, valves located in a valve block monolith adjacent to the lock walls control water flow to and from the water saving basins. These valves connect the chamber to the basins through transverse flow culverts called "conduits", named so to differentiate them from the longitudinal flow culverts. The type of culvert and conduit valve selected by the conceptual designers for the Atlantic locks filling and emptying system is a wheel type, vertical lift valve, driven by hydraulic cylinders similar to the ones used in the rising stem valves of the Panama Canal locks.

For the Atlantic Locks three-lift design, 16 culvert valves and 24 conduit valves would be needed. Table 8.3 shows their estimated required dimensions and weights:

Valves ID	Hydraulic Head (m)	Width (m)	Height (m)	Weight (tons)
Culvert Lower level (4 ea.)	13.5	5.0	8.0	63.2
Culvert Middle level (8 ea.)	27	4.0	8.0	50.5
Culvert Upper level (4 ea.)	27	4.0	8.0	50.5
WSB Conduits (24 ea.)	6.7	6.0	8.0	38.5

Table 8.3. Culvert and conduit valves estimated dimensions and weights for the Atlantic locks

- **Installation Procedure**

A basic assumption of this cost estimating / scheduling effort is that both the Culvert and Conduit valves and their operating equipment (hydraulic cylinders and power units, etc.) would be constructed in an international steel works shop that would have enough capacity to produce the valves within the required timeframe. They would be transported to Panama as single units in a cargo vessel and unloaded at the materials handling dock built for the lock construction project, located north of the Atlantic entrance channel on the east bank of the Canal. They would be loaded to flat bed trailer trucks that would transport them close to the construction site.

Once the respective gate bay monolith (culvert valves) and valve block monolith (conduit valves) civil works are completed (which includes the installation of all embedded metals, bottom and top seals, vertical guide rails, etc.) the valve body would be lowered into the valve slot into its closed position by a 60-ton (or 40-ton, as needed) crane located on top of the gate bay monolith or valve block. Sealing would be adjusted and the hydraulic cylinder would be lowered and positioned with the crane and secured on the concrete slab on top of the valve body. The installation of the hydraulic power units and electrical controls panel would be completed inside the respective valve rooms at the operating gallery level. Operating manually, the cylinder's rod would be extended and mechanically connected to the valve body. Testing of the equipment may follow. The installation would start with the culvert valves of gate bay monolith 3, followed successively by: gate bay monolith 2, 4 and 1. The Conduit valves installation would start in chamber 3-valve block monolith followed by chamber 2 and 1. The culvert valves of gate bay monolith 1 are the most critical because they do not have slack time. Additionally, two and a half months are scheduled for the necessary testing and finishing touches of the installation before the culvert valves final commissioning. The conduit valves have a 4.5-month time slot scheduled for testing.

The time frame scheduled for each valve installation is summarized in Table 8.6.

Valve type	Location	Time available for the installation
Culvert (4 ea.)	Gate Bay 4	6 months
Culvert (4 ea.)	Gate Bay 3	6 months
Culvert (4 ea.)	Gate Bay 2	6 months
Culvert (4 ea.)	Gate Bay 1	6 months
Conduit (8 ea.)	Valve Block Monolith Chamber 3 Lower level	31months
Conduit (8 ea.)	Valve Block Monolith Chamber 2 Middle level	17 months
Conduit (8 ea.)	Valve Block Monolith Chamber 1 Upper level	4 months

Table 8.6. Atlantic Locks Culvert and Conduit valves location and time available for the installation

10.1.3 Electrical Equipment: Lighting, Power and Control

- **Description**

The lighting equipment needed for the Atlantic Lock is listed and detailed in Table 8.7.

Item	Unit	Quantity	Total	Type
High Mast Lighting Poles	ea.	44	61	45.7 m tall, hot dipped galvanized steel
High Mast Lighting Lamps	ea.	288	288	1000 W, HPS, 100 lux working area illumination
High Mast Lowering device	ea.	2	2	**(not included)**
Gate floodlights	ea.	2	32	750 W, HPS floodlights
Gate poles	ea.	16	16	9.14 m tall
Chamber flood lights	ea.	24	144	400W, HPS floodlights
Gate Technical room lights	ea.			
Technical room lights	ea.			
Maintenance Building lights	ea.			

Cable Tray tunnels	m		8500	
Cross over cable tray	m	3	1095	

Table 8.7. Atlantic Locks Lighting Equipment Description

The electrical power equipment needed for the Atlantic Lock is listed and detailed in Table 8.8.

Item	**Unit**	**Quantity/ HV room**	**Total**	**Type**
High Voltage Switchgear	ea.	1	2	Metal enclosed cubicle, equipment air vaccum type circuit breakers, 15,000 / 6,900 V; 1200 A
Low Voltage Switchgear	ea.	1	23	Metal enclosed cubicle, air vaccum high voltage circuit breakers, 6,900 / 480 V; 1600 A
Track Transformers	ea.	12	24	225 kVA, 6900 V / 480 V , delta -star
Standby Transformer	ea.			
Machinery Transformers	ea.	2	22	750 kVA, 6900 V /480 V , delta -delta
Standby Transformer	ea.			
Transformers	ea.			
Standby Transformer	ea.			
Emergency Diesel Set	ea.			
Sectionalizing Switches	ea.	2	16	15kV, 600 A
Loop Feeders	**Unit**	**Quantity/ HV room**	**Total**	**Type**
HV feeders	m	3	6000	500 kcmil, 8kV shielded, 133% insulation, type MV-105, EPR insulation, CSPE jacket
LV Loop feeders	m	3	25000	500 kcmil, 8kV shielded, 133% insulation, type MV-105, EPR insulation, CSPE jacket
Low voltage cables	m	ls	ls	12 AWG, Multicore, 3 conductors per cable, Cu or Al,
Low voltage macinery cables	m		2400	4/0 & 500 AWG, 8kV shielded, 133% insulation, type MV-105, EPR insulation, CSPE jacket

Table 8.8. Atlantic Locks Electrical Power Equipment Description

The electrical control equipment needed for the Atlantic Lock is listed and detailed in Table 8.9.

Item	Unit	Quantity	Total	Type
PLC	ea.	56	56	Includes: enclosure, power supply, CPU, I/O cards, ethernet & communication cards
PLC displays	ea.	56	56	
Workstations	ea.	2	2	inc. 21" display screen with keyboards, mouse
Printers	ea.	3	3	
Projection Screen	ea.			
Engineering Station	ea.	1	1	inc. 21" display screen with keyboards, mouse
Local Control Panels	ea.	56	56	
CCTV system				
Fiber Optic cables	m	2	5500	
Fiber Optic cables network equipment	ea.	1	1	

Table 8.9. Atlantic Locks Electrical Control Equipment Description

- **Installation Procedure**
  A basic assumption of this cost estimating / scheduling effort is that an electrical sub-contractor would be tasked with the installation of the electrical equipment and that the equipment would be imported because of its specialized nature.

10.1.4 Lightning Equipment

The 45.7 m high mast poles would be installed once the top of wall concrete slab is cured. The poles would be positioned on a prefabricated base (part of the concrete slab design) that has the required anchor bolts with the help of a 20-ton crane and secured in place. With the portable lowering device, the lamp ring would be lowered and the HPS lamps installed. The electrical feed would be connected to a distribution panel located in the closest transformer room. Chamber floodlights could also be installed once the chamber top of wall concrete slab is finished, they would be positioned in special recesses specifically designed to keep them away from any possible vessel contact. The electrical feed would be connected to a distribution panel located in the closest transformer room. The gate floodlights would be installed once the miter gates are in place. The electrical feed runs along the gate in special conduits and would be connected to a distribution panel located in the machinery transformer room. The lighting required for each building would be installed once the construction of the structure.

High masts with the least available time for installation are the ones located in the upper level or Chamber 1 and the Gatun approach wall. Six months are available for this installation. There is ample time for the installation of the remaining lighting equipment.

10.1.5 Electrical Power Equipment

All the switchgears, transformers, sectionalizing switches and emergency generators would be placed in their respective transformer rooms located in the operating gallery tunnel. This can be accomplished with a 20-ton crane. The timing of the installation would depend on the construction of the room since the equipment has to be placed inside, before the room's roof is installed. For the switchgears and transformers the critical minimum allotted time is 1 month for the transformer rooms feeding the miter gates of GB 1.

The electric gallery runs on the top of the wall concrete slab. Once finished, the installation of the cable trays could start and when the tray is ready the loop feeders and the rest of the required electrical wiring along with the compressed air piping would be run or installed. A minimum time of 2 months would be allotted for this task.

10.1.6 Electrical Control Equipment

The electric gallery runs on the top of the wall concrete slab. Once finished, the installation of the cable trays could start and when the tray is ready the fiber optics cable loops would be run or installed. A minimum time of 2 months is allotted for this task. Control PLCs are located inside the gates and valves local control panel. PLCs have to be wired (fiber optics cable) and powered (electric cables) along with the installation of the hydraulic power units. Additional control equipment would be installed inside the specific machinery local control rooms when these are finished. For this task, the critical minimum allotted time is 2 months for the transformer room feeding the miter gates of GB 1.

The main computer, PLCs, screens, UPS, fiber optic rack modules, CCTV, etc., would be installed inside the Central Control building. As soon as the building is finished, it could be wired and the equipment installed so that it would be ready to start remote testing and operation of the machinery. At least 9 months are available for these installations before the first set of miter gates are remotely tested.

Appendix A -Atlantic Cost Estimate Backup

A	CIVIL WORKS							
Sec No.	**Pay Item No.**	**ITEM**	**Pay Unit**	**Quantity**	**UNIT PRICE**	**AMOUNT TOTAL (us$)**	**LOCAL CURRENCY (us$Eq)**	**FOREIGN CURRENCY (US$)**
		MOB AND DEMOB - LOCKS	ls	1	88,488,609	**88,488,609**	71,237,048	17,251,560
1		**MOBILIZATION AND DEMOBILIZATION**	ls	1	88,488,609	**88,488,609**	71,237,048	17,251,560
		DIVERSION & CARE OF WATER - LOCKS	ls	1	21,173,104	**21,173,104**	10,047,453	11,125,651
2		**DIVERSION AND CARE OF WATER**	ls	1	21,173,104	**21,173,104**	10,047,453	11,125,651
						-		
3		**DRY EXCAVATION WORK - LOCKS**						
	3.1.	**Excavate & Haul Overburden**	bm^3	6,773,900	5.11	34,621,899	6,928,229	27,693,669
	3.2.	**Excavate & Haul Weathered Rock**	bm^3	10,188,000	6.88	70,097,629	14,974,339	55,123,290
	3.3.	**Excavate & Transport Rock - Mass Exc**	bm^3	-	-	-	-	-
	3.4	**Excavate & Haul Rock - For Aggregates**	bm^3	-	-	-	-	-
	3.5	**Excavate and Haul Structural Rock**	bm^3	-	-	-	-	-
		Total Dry Excavation Locks				**104,719,527**	21,902,568	82,816,959
						-		
3		**TOTAL DRY EXCAVATION**				**104,719,527**	**21,902,568**	**82,816,959**
						-		
						-		
						-		
4		**EMBANKMENTS AND FILLS**						
	4.1	**Common Fills**	fm^3	1,155,989	0.84	966,588	276,189	690,400
	4.2	**Granular Fills**	fm^3	724,628	13.99	10,137,335	7,835,343	1,201,241
						-		
4		**TOTAL EMBANKMENTS AND FILLS**				**11,103,924**	**8,111,531**	**1,891,640**
5		**PERMANENT SITE WORK - LOCKS**						
	5.1	**Clearing& grubbing**	hct	200	2,323	464,528	464,528	-
	5.2	**Roads**	km	5	794,588	4,171,586	4,171,586	-
	5.3	**Demolitions**	m3	3,750	489	1,833,664	1,833,664	-
	5.4	**Temporary Relocations**	ea	75	1,222	91,683	91,683	-
	5.5	**Permanent Relocations**	ea	75	2,445	183,366	183,366	-
	5.6	**Utilities**	ls	1	1,222,443	1,222,443	1,222,443	-
	5.7	**Preparation of Disposal Areas**	hct	305	6,112	1,864,225	1,864,225	-
	5.8	**Restoration of Disposal Areas**	hct	305	12,224	3,728,450	3,728,450	-
		TOTAL PERMANENT SITE WORK - LOCKS				13,559,945	13,559,945	-
5		**TOTAL PERMANENT SITE WORK**				**13,559,945**	**13,559,945**	-
6		**CAST IN PLACE CONCRETE WORK**						
	6.1	**Cast in Place Approach Walls**	m^3	116,322	111.26	12,941,412	8,080,086	4,861,326
	6.2	**Cast in Place Lock & Gate Chamber Walls**	m^3	1,958,551	85.63	167,718,099	106,668,558	61,049,541
	6.3	**Cast in Place Lock & Gate Chamber Floors**	m^3	315,446	90.12	28,428,708	18,260,311	10,168,396
	6.4	**Cast in Place WSB Walls**	m^3	12,246	213.00	2,608,423	1,625,004	983,419
	6.5	**Cast in Place WSB Floors**	m^3	183,397	161.13	29,550,574	19,185,071	10,365,503
	6.6	**Reinforcing steel**	ton	52,772	2,505.64	132,227,928	27,530,991	104,696,936
	6.7	**Straight Forms**	m^2	550,007	148.28	81,555,170	48,085,694	33,469,476
	6.8	**Curved Forms**	m^2	98,825	244.72	24,184,841	16,681,367	7,503,474
	6,10	**Shotcrete**	m^3	20,000	180.59	3,611,899	2,264,398	1,347,500
	6.11	**Lean Concrete**	m^3	30,687	174.19	5,345,463	**3,265,277**	**2,080,186**
6		**TOTAL CAST IN PLACE CONCRETE WORK**		-		**488,172,516**	**251,646,757**	**236,525,758**
						-		
						-		
						-		
7		**ROLLER COMPACTED CONCRETE (RCC)**						
	7.1	**RCC Approach Walls**	m^3	611,089	63.64	38,887,172	24,762,161	14,125,011
	7.2	**RCC Lock Walls**	m^3	985,402	63.64	62,706,884	39,929,824	22,777,059
	7.4	**RCC WSB Floors**	m^3	-	-	-	-	-
7		**TOTAL ROLLER COMPACTED CONCRETE (RCC)**				**101,594,055**	**64,691,985**	**36,902,071**
		TOTAL CIVIL WORKS - LOCKS				**828,811,680**	**441,197,288**	**386,513,640**
A		**CIVIL WORKS**				**828,811,680**	**441,197,288**	**386,513,640**

DESCRIPTION	EA	WT/EA TON	TOTAL WT TON
GATE 1 T1	4	1,208	4,832
GATE 2 T2	4	1,474	5,896
GATE 3 T3	4	1,474	5,896
GATE 4 T4	4	1,474	5,896
TOTAL	**8**		**22,520**

	Description	Unit	Qty	Rate us$/unit	Amount us$	Price us$/ton	%
	GATES						
1	**Manufacture**						
	Steel	ton	24,997	916.7	22,914,100		
	Chains/Pins & Rollers	ton	0	4,500	0		
	Welding Rod	ton	2,815	2,500	7,037,500		
	Shop Paint	m2	315,280	55	17,340,400		
	Manufacture Labor	mh	1,013,400	18.5	18,747,900		
	Plant & Equipment	days	751	15,500	11,635,333		
					77,675,233		
	Cost FOB Shop	Ohs + Profit		1.60	124,280,373	5,519	64.97
							-
2	**Transport & Handle**						-
	Transport to Site	ton	22,520	600	13,512,000		-
	Unload/ Store & Handle	ton	22,520	50	1,126,000		-
							-
	Transport & Handle				14,638,000	650	7.65
							-
3	**Installation**						-
	Labor	mh	80,000	25	2,000,000		-
	Equipment	hr	5,004	3,200.00	16,014,222		-
	Welding Rod	ton	337.8	2,500.00	844,500		-
	Field Paint	m2	315,280	35.33	11,138,842		-
	Testing	ea	8	200,000.00	1,600,000		-
	Misc Supplies	ls	1	1,126,000.00	1,126,000		-
							-
					32,723,565		-
		Ohs + Profit		1.60	52,357,703	2,325	27.37
							-
	Cost Manufacturing & Installation				**191,276,077**	8,494	100.00
4	**Operating Machinery**						
	Furnish Operating Machinery	ea	8	1,000,000	8,000,000		
	Installation Labor	mh	0	25	0		
	Installation P/E	hr	0	250	0		
					8,000,000		
		Ohs + Profit		1.45	**11,600,000**		
	Total Furnishing & Installation of Gates				**202,876,077**		

LABOR	EA	US$/HR	TOTAL
LOCAL	9	7.80	70.20
FOREIGN	1	35.00	35.00
	10	10.52	105.2

Structural Steel Fabrication 3383.3 US$/ton

DESCRIPTION	EA	TONS (EA.)	TONS	INSTALL LABOR MH/EA	INSTALL LABOR US$/EA	INSTALL M&S US$/EA	PURCHASE US$/EA	TOTAL DIR COST US$/EA	TOTAL OH's + FEE US$/EA	TOTAL PRICE US$/EA	TOTAL AMOUNT US$
Gate 1 East Main Culvert Blkhd	4	63.2	252.8	1900	19,988	1580	271,758	293,326	117,330	410,656	1,642,625
Gate 1 West Main Culvert Blkhd	4	63.2	252.8	1900	19,988	1580	271,758	293,326	117,330	410,656	1,642,625
TOTAL MAIN CULVERT BULKHEADS	**8**		**505.6**								**3,285,250**
Chamber 1 North WSB Upper Blkhd	4	38.52	154.08	1200	12,624	963	165,635	179,222	71,689	250,910	1,003,642
Chamber 1 North WSB Lower Blkhd	4	38.52	154.08	1200	12,624	963	165,635	179,222	71,689	250,910	1,003,642
Chamber 1 South Upper Blkhd	4	38.52	154.08	1200	12,624	963	165,635	179,222	71,689	250,910	1,003,642
Chamber 1 South Lower Blkhd	4	38.52	154.08	1200	12,624	963	165,635	179,222	71,689	250,910	1,003,642
TOTAL WSB BULKHEADS	**16**		**616.32**								**4,014,566**
TOTAL BULKHEADS FOR LOCKS	**24**		**1121.92**								**7,299,816**

LABOR	EA	US$/HR	TOTAL
LOCAL	6	9.50	57.00
FOREIGN	1	40.00	40.00
	7	13.86	97.00

Structural Steel Fabrication 5183.3

DESCRIPTION	EA	TON (EA.)	TONS	INSTALL LABOR MH/EA	INSTALL LABOR US$/EA	INSTALL M&S US$/EA	PURCHASE US$/EA	TOTAL DIR COST US$/EA	TOTAL OH's + FEE US$/EA	TOTAL PRICE US$/EA	TOTAL AMOUNT US$
Gate 1 East Main Culvert Valve	2	63.2	126.4	400	5,543	5,688	385,518	396,749	178,537	575,286	1,150,571
Gate 1 West Main Culvert Valve	2	63.2	126.4	400	5,543	5,688	385,518	396,749	178,537	575,286	1,150,571
Gate 2 East Main Culvert Valve	2	50.47	100.94	400	5,543	4,542	307,865	317,950	143,078	461,028	922,056
Gate 2 West Main Culvert Valve	2	50.47	100.94	400	5,543	4,542	307,865	317,950	143,078	461,028	922,056
Gate 3 East Main Culvert Valve	2	50.47	100.94	400	5,543	4,542	307,865	317,950	143,078	461,028	922,056
Gat3 3 West Main Culvert Valve	2	50.47	100.94	400	5,543	4,542	307,865	317,950	143,078	461,028	922,056
Gate 4 East Main Culvert Valve	2	50.47	100.94	400	5,543	4,542	307,865	317,950	143,078	461,028	922,056
Gate 4 West Main Culvert Valve	2	50.47	100.94	400	5,543	4,542	307,865	317,950	143,078	461,028	922,056
TOTAL MAIN CULVERT VALVES	16		858.44								7,833,481
Chamber 1 North WSB Upper Valve	2	38.52	77.04	600	8,314	3,467	234,971	246,752	111,038	357,790	715,580
Chamber 1 North WSB Lower Valve	2	38.52	77.04	850	11,779	3,467	234,971	250,216	112,597	362,813	725,627
Chamber 1 South WSB Upper Valve	2	38.52	77.04	600	8,314	3,467	234,971	246,752	111,038	357,790	715,580
Chamber 1 South WSB Lower Valve	2	38.52	77.04	850	11,779	3,467	234,971	250,216	112,597	362,813	725,627
Chamber 2 North WSB Upper Valve	2	38.52	77.04	600	8,314	3,467	234,971	246,752	111,038	357,790	715,580
Chamber 2 North WSB Lower Valve	2	38.52	77.04	850	11,779	3,467	234,971	250,216	112,597	362,813	725,627
Chamber 2 South WSB Upper Valve	2	38.52	77.04	600	8,314	3,467	234,971	246,752	111,038	357,790	715,580
Chamber 2 South WSB Lower Valve	2	38.52	77.04	850	11,779	3,467	234,971	250,216	112,597	362,813	725,627
Chamber 3 North WSB Upper Valve	2	38.52	77.04	600	8,314	3,467	234,971	246,752	111,038	357,790	715,580
Chamber 3 North WSB Lower Valve	2	38.52	77.04	850	11,779	3,467	234,971	250,216	112,597	362,813	725,627
Chamber 3 South WSB Upper Valve	2	38.52	77.04	600	8,314	3,467	234,971	246,752	111,038	357,790	715,580
Chamber 3 South WSB Lower Valve	2	38.52	77.04	850	11,779	3,467	234,971	250,216	112,597	362,813	725,627
TOTAL WSB VALVES	24		924.48								8,647,241
TOTAL VALVES FOR LOCK	40		1782.92								16,480,722
Valve Operating Machinery	40			400	5,543	1,000	230,000	236,543	106,444	342,987	13,719,486
											30,200,208

SUMMARY OF GENERAL ADMINISTRATIVE COSTS & FEES

Cod No.	Description	Un	Qty mm	Local us$	Foreign us$	Total us$
A	**Personnel**					
	Administrative	ea	32	2,020	1,638,900	6,709,500	8,348,400
	Construction Supervision	ea	94	4,648	3,960,900	18,983,610	22,944,510
	Construction Engineering	ea	51	3,071	1,986,957	6,214,950	8,201,907
	Office/ Accounting & Warehousing	ea	58	3,265	3,098,784	1,386,450	4,485,234
	Purchasing	ea	14	806	504,000	991,800	1,495,800
	Industrial Security & Labor Relations	ea	50	2,736	2,269,350	468,000	2,737,350
	Guards	ea	25	1,469	1,085,568	0	1,085,568
	Maint. Temporary Facilities	ea	29	1,390	1,680,528	0	1,680,528
	Sub-Total Local Personnel	ea	286	15,761			
	Sub-Total Foreign Personnel	ea	67	3,643			
			353	19,404			
A	**Total Personnel**	**ea**	**353**	**19,404**	**16,224,987**	**34,754,310**	**50,979,297**
B	**Total Depr & Operation General P/E**				**19,372,220**	**21,706,912**	**41,079,132**
C	**Construction Temporary Facilities**						
	Temporary Project Access				30,886,974	0	30,886,974
	Plant Instalation				8,991,255	599,295	9,590,549
	Buildings				4,292,707	693,783	4,986,490
	General Utilities				8,570,308	2,300,451	10,870,759
	Worker's Camp				0	0	0
C	**Total Construction of Temporary Facilities**				**52,741,244**	**3,593,530**	**56,334,773**
D	**Total Maintenance of Temporary Facilities**				**5,498,426**	**495,144**	**5,993,570**
E	**Mobilization & Demobilization**						
	Personnel				418,750	1,675,000	2,093,750
	P/E				2,347,801	1,779,643	4,127,444
	Demob. P/E & Personnel				2,766,551	2,666,756	5,433,307
E	**Total Mobilization & Demobilization**				**5,533,103**	**6,121,399**	**11,654,502**
F	**General Services and Supplies**				**2,574,076**	**2,123,016**	**4,697,092**
G	**Taxes**				**29,413,081**	**0**	**29,413,081**
H	**Insurances and Guaranties**				**7,200,000**	**16,500,000**	**23,700,000**
I	**Interest During Construction**				**0**	**0**	**0**
	Total Taxes/Insurances/Guarantees/Interest				**36,613,081**	**16,500,000**	**53,113,081**
	TOTAL OVERHEADS				**138,557,135**	**85,294,311**	**223,851,447**
J	**Home Office**				-	**25,000,000**	**25,000,000**
K	**Fees**				-	**68,275,543**	**68,275,543**
	Total Home Office Overheads & Fees				**-**	**93,275,543**	**93,275,543**
	TOTAL OVERHEADS & FEES (INCL MOB & DEMOB)				**138,557,135**	**178,569,854**	**317,126,990**

Appendix B - Atlantic Concrete Backup

Concrete Volume Calculations

		Station	Section m²	Length m	Other vol. m³	Volume m³
	11 Chamber 1 East					**330,995**
	Chamber 1 "RCC"					**208,214**
East	Section A	st 13+134				
	Section B	st 13+175		42		0
	Section B	st 13+175 - st 13+428	615	253		155,515
	Section B	st 13+428	615			
	Section A	st 13+504	772	76		52,698
	Section A	st 13+504 - st 558		54		0
	Chamber 1 "Conventional concrete"					**122,782**
	Section A	st 13+134	877			
	Section B	st 13+175	735	42		33,863
	Section B	st 13+175 - st 13+428	121	253		30,542
	Section B	st 13+428	121			
	Section A	st 13+504	169	76		11,010
	Section A	st 13+504 - st 558	877	54		47,366
	12 Chamber 1 West					**291,129**
	Chamber 1 "RCC"					**110,674**
West	Section A	st 13+134				
	Section B	st 13+175		42		0
	Section B	st 13+175 - st 13+275	538	100		53,832
		st 13+275 - st 13+405		130		0
		st 13+405 - st 13+429	538	24		12,920
	Section B	st 13+428	538			
	Section A	st 13+504	618	76		43,923
	Section A	st 13+504 -		54		0

		st 558				
	Chamber 1 "Conventional concrete"					**180,455**
	Section A	st 13+134	729			
	Section B	st 13+175	659	42		29,148
	Section B	st 13+175 - st 13+275	121	100		12,095
		st 13+275 - st 13+405	659	130		85,705
		st 13+405 - st 13+429	121	24		2,903
	Section B	st 13+428	121			
	Section A	st 13+504	175	76		11,253
	Section A	st 13+504 - st 558	729	54		39,352
	Conduct valve building and culvert section	**st 13+275 - st 13+405**	**720**	**130**	**6,154**	**99,813**
WS B						**64,546**
	3A walls section 1		2	643		1,513
	3A footing		5	643		3,015
	3A floor		29,738	0.5		14,869
	3B walls section 1		2	241.5		560
	3B walls section 2		5	404.0		2,050
	3B footing section 1		5	241.5		1,132
	3B footing section 2		8	404.0		3,248
	3B floor		31,606	0.5		15,803
	Conducts		39	568		22,356
	13 Chamber 2 East		353,160			**349,893**
	Chamber 2 "RCC"					**221,557**
East	Section A	st 13+649				
	Section B	st 13+691		42		0
	Section B	st 13+691 - st 13+944	658	253		166,522
	Section B	st 13+944	658			
	Section A	st 14+020	790	76		55,035
	Section A	st 14+020 - st 14+074		54		0
	Chamber 2 "Conventional concrete"					**128,336**
	Section A	st 13+649	905			

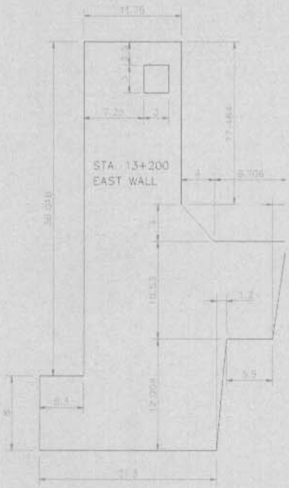
	Section B	st 13+691	786	42		35,504
	Section B	st 13+691 - st 13+944	128	253		32,336
	Section B Section A	st 13+944 st 14+020	128 179	76		11,643
	Section A	st 14+020 - st 14+074	905	54		48,853
	14 Chamber 2 West	**292,487.00**				**286,931**
	Chamber 2 "RCC"					**109,453**
West	Section A Section B	st 13+649 st 13+691		42		0
	Section B	st 13+691 - st 13+791	531	100		53,055
		st 13+791 - st 13+921		130		0
		st 13+691 - st 13+946	531	24		12,733
	Section B Section A	st 13+944 st 14+020	531 619	76		43,665
	Section A	st 14+020 - st 14+074		54		0
	Chamber 2 "Conventional concrete"					**177,478**
	Section A Section B	st 13+649 st 13+691	730 646	42		28,880
	Section B	st 13+691 - st 13+791	115	100		11,494
		st 13+791 - st 13+921	646	130		83,915
		st 13+691 - st 13+946	115	24		2,759
	Section B Section A	st 13+944 st 14+020	115 175	76		11,026
	Section A	st 14+020 - st 14+074	730	54		39,405
	Conduct valve building and culvert section	**st. 13+791 -st 13+921**	**720**	**130**	**6,154**	**99,813**
WS B						**64,499**
	2A walls section 1		2	643		1,590
	2A footing		5	643		3,015

	2A floor		29,738	0.5		14,869
	2B walls section 1		2	241.5		592
	2B walls section 2		5	404.0		1,844
	2B footing section 1		5	241.5		1,132
	2B footing section 2		8	404.0		3,248
	2B floor		31,705	0.5		15,852
	Conducts		39	568		22,356
	15 Chamber 3 East		392,317			**356,804**
	Chamber 3 "RCC"					**226,002**
East	Section A	st 14+165				
	Section B	st 14+207		42		0
	Section B	st 14+207 - st 14+460	671	253		169,806
	Section B	st 14+460	671			
	Section A	st 14+536	808	76		56,196
	Section A	st 14+536 - st 14+590		54		0
	Chamber 3 "Conventional concrete"					**130,803**
	Section A	st 14+165	924			
	Section B	st 14+207	801	42		36,228
	Section B	st 14+207 - st 14+460	130	253		32,890
	Section B	st 14+460	130			
	Section A	st 14+536	180	76		11,791
	Section A	st 14+536 - st 14+590	924	54		49,894
	16 Chamber 3 West		293,700.0			**289,642**
	Chamber 3 "RCC"					**109,502**
West	Section A	st 14+165				
	Section B	st 14+207		42		0
	Section B	st 14+207 - st 14+307	530	100		53,041
		st 14+207 - st 14+437		130		0
		st 14+437 - st 14+460	530	24		12,730
	Section B	st 14+460	530			
	Section A	st 14+536	620	76		43,730
	Section A	st 14+536 -		54		0

		st 14+590				
	Chamber 3 "Conventional concrete"		693			**180,140**
	Section A	st 14+165	733			
	Section B	st 14+207	653	42		29,106
	Section B	st 14+207 - st 14+307	123	100		12,255
		st 14+207 - st 14+437	653	130		84,885
		st 14+437 - st 14+460	123	24		2,941
	Section B	st 14+460	123			
	Section A	st 14+536	177	76		11,369
	Section A	st 14+536 - st 14+590	733	54		39,583
	Conduct valve building and culvert section	**st 14+307 - st 14+437**	**720**	**130**	**6,154**	**99,813**
WS B						**64,570**
	3A walls section 1		2	643		1,590
	3A footing		5	643		3,015
	3A floor		29,738	0.5		14,869
	3B walls section 1		3	241.5		625
	3B walls section 2		5	404.0		1,882
	3B footing section 1		5	241.5		1,132
	3B footing section 2		8	404.0		3,248
	3B floor		31,705	0.5		15,852
	Conducts		39	568		22,356
	Gate Bay 1					**199,200**
East	"RC"		97,882.0			
	Section B	st 13+043 - st 13+134	1,278	90.8	-16,425	99,600
West	"RC"					
	Section B	st 13+043 - st 13+134	1,278	90.8	-16,425	99,600
	Gate Bay 2		97,882			**199,200**
East	"RC"					
	Section B	st 13+558 - st 13+649	1,278	90.8	-16,425	99,600
West	"RC"					

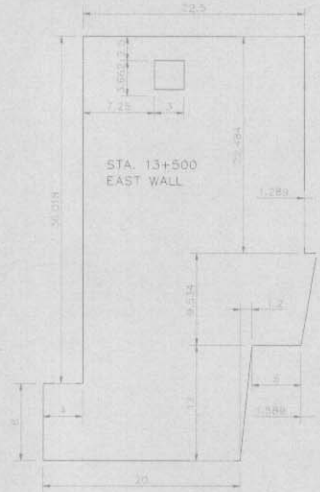
	Section B	st 13+558 - st 13+649	1,278	90.8	-16,425	99,600
	Gate Bay 3		97,882			**199,200**
East	"RC"					
	Section B	st 14+074 - st 14+165	1,278	90.8	-16,425	99,600
West	"RC"					
	Section B	st 14+074 - st 14+165	1,278	90.8	-16,425	99,600
	Gate Bay 4		72,277			**141,519**
East	"RC"					
	Section B	st 14+590 - st 14+681	922	90.8	-12,976	70,759
West	"RC"					
	Section B	st 14+590 - st 14+681	922	90.8	-12,976	70,759
	Total concrete volume					**3,137,568**

Chamber 1
2.1.3.1.2 Section B, East

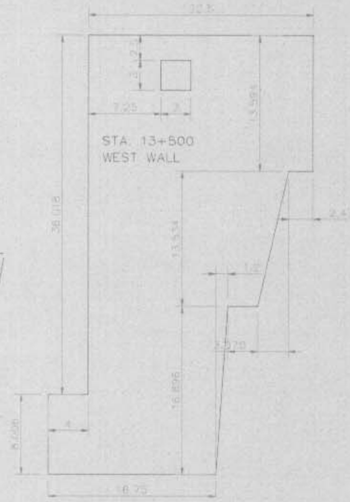


Chamber 1
2.1.3.1.3 Section

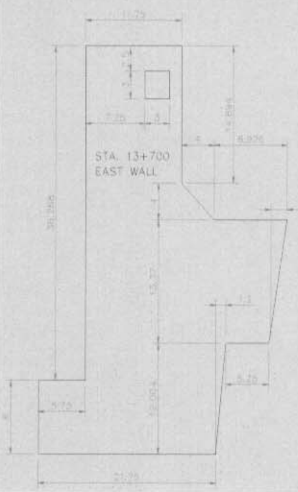
Chamber 1
2.1.3.1.4 Section A, East



Chamber 1
2.1.3.1.5 Section A West

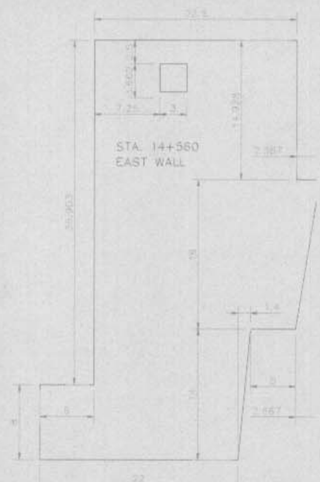


Chamber 2
2.1.3.1.6 Section B East

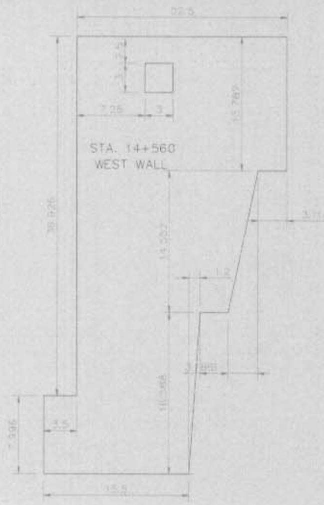


Chamber 2
2.1.3.1.7 Section

Chamber 3
2.1.3.1.8 Section A, East



Chamber 3
2.1.3.1.9 Section A, West



Appendix C - Excavation Backup

Geological Considerations

Rock formations over the entire Atlantic locks and approach channels are of sedimentary origin. All are part of the Gatun Formation. In general, the Gatun Formation is made up of argillaceous and tuffaceous sandstones, volcanic tuffs and conglomerates. The strata were formed in a marine environment but the primary source of deposited material was sporadic volcanic eruptions.

There were four separate geologic phases for the development of the top rock surface at the site:

- The bedrock (Gatun Formation) was formed by the consolidation of volcanic detritus that had been deposited in a shallow marine environment.
- The sea level receded and bedrock became subject to erosion, forming a typical surface topography of small hills separated by valleys. The bedrock weathered forming a layer of residual soil that conformed the Gatun Overburden.
- The sea again encroached submerging the ground surface in a shallow marine environment. Sediment deposition occurred again. The material deposited was a soft highly organic, highly plastic clay and silt known as Atlantic Muck. This deposition resulted in a relatively flat ground surface that covered the original hill and valley topography.
- The land surface again emerged above sea level and erosion processes continue resulting in the present topography.

The strata can be separated in several units. The residual silt, clay and spoil from the 1939 Third Locks excavation overlie the older material. The Atlantic Muck, which was deposited when the sea inundated the site, is present only at elevation near sea level. The Gatun overburden is a regolith of residual soil that had formed above the underlying rock before the sea inundated the site. The Gatun formation bedrock consist of tuffaceous sandstone, conglomerate, pumiceous sandstone and pumiceous tuff. Generally the bedding is massive but there are areas of finely laminated deposits within the strata.

Appendix D - Atlantic Electromechanical Backup

The principal characteristics of the valves operating machinery are summarized in Tables 8.4. and 8.5.

Culvert Valves

Item	Unit	Quantity/valve	Total	Type
Hydraulic cylinder	ea.	1	16	457 mm bore, 165 mm rod, 8.23 m stroke
Motor	ea.	2	32	93 kW, 3 ph., 1800 rpm, AC, 60 Hz, 480 V
Hydraulic Power unit	ea.	1	16	4542 l reservoir, design pressure 17.2 MPA, 24.1 MPA peak pressure
Local Control Panel	ea.	1	16	

Table 8.4. Culvert valves operating machinery description for the Atlantic Locks

Conduit Valves

Item	Unit	Quantity/valve	Total	Type
Hydraulic cylinder	ea.	1	24	457 mm bore, 165 mm rod, 8.23 m stroke
Motor	ea.	2	48	93 kW, 3 ph., 1800 rpm, AC, 60 Hz, 480 V
Hydraulic Power unit	ea.	1	24	4542 l reservoir, design pressure 17.2 MPA, 24.1 MPA peak pressure
Local Control Panel	ea.	1	24	

Table 8.5. Conduit valves operating machinery description for the Atlantic Locks

Appendix E - Atlantic Utilities Relocation Backup

Water Utilities:

For cost estimating purposes, it was assumed that approximately 1,000 m. of 0.3-m.φ class 50, M-J'd., cement-lined ductile iron pipe complete with one (1) 0.3-m.φ tee, one (1) 0.3-m.φ wye, five (5) 0.3-m.φ 90° long radius elbows and two (2) 0.3-m.φ R.S. gate valves and 1,700 m. of 0.2-m.φ B&S, DWV cast iron sewer pipe complete with one (1) 0.2-m.φ tee and two (2) 0.2-m.φ 90° elbows would be laid out in the field at an approximate 350 m. long 1.0-m. wide x 1.0-m. deep ditch, and through the new locks' water utilities cross-under, for the 0.3-m.φ potable water line and at an approximate 1,700 m. long 1.0-m. wide x 1.0-m. deep ditch for the 0.2-m.φ sewage line, respectively. Additionally, it was assumed that the whole length of the bottom of both ditches is bedded with non-compacted, 0.15-m. deep, 15/20-mm. crushed stone and mechanically back-filled with non-compacted common earth. Additionally, it was also assumed that two (2) 0.3-m.φ control R.S. gate valves and two (2) 0.3-m.φ blind flanges would be required to complete the permanent water utilities relocation.

The total water demand is estimated as follows:

Daily Industrial Usage Water Demand

± 0.926000 MGD (R.C. & R.C.C. Concrete Mixing & Joint Prep.)
± 1.141347 MGD (Coarse Aggregate Washing)
± 0.019530 MGD (Drilling and Blasting)
± 2.086877 MGD **Total Estimated Daily Industrial Usage Water Demand**

Daily Human Consumption Water Demand

± 0.190225 MGD (Workers' Drinking and Bathing)
± 0.190225 MGD **Total Estimated Daily Human Consumption Water Demand**

Electric Utilities:

The total electric energy demand is estimated as follows:

100% Average Load Total Electric Energy Demand:

± 1.20 MVA (Load Type I-Const. Camp Lighting, A/C, I/M & Telecom)
\+ ± 0.00 MVA (Load Type I-Channel Exc. Site Lighting)
\+ ± 2.00 MVA (Load Type I-Const. Site Lighting)

= ± 3.20 MVA **Total Estimated 100% Average Electric Energy Demand**

80% Average Load Total Electric Energy Demand:

± 1.64 MVA (Load Type II-Const. Site Dewatering Pump Bks.)
\+ ±7.00 MVA (Load Type III-Const. Camp Conc. & Aggreg's. Plants)
\+ ± 2.48 MVA (Load Type III-Const. Site Concrete Placing)
\+ ± 3.60 MVA (Load Type III-Const. Site & Const. Camp Compressed Air)

= ±14.72 MVA **Total Estimated 80% Average Electric Energy Demand**

60% Average Load Total Electric Energy Demand:

± 0.47 MVA (Load Type IV-Const. Camp Shop Equipment)
± 0.47 MVA **Total Estimated 60% Average Electric Energy Demand**