PDHonline Course C739 (8 PDH)

A New Set of Locks at the Panama Canal

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"A NEW SET OF LOCKS AT THE PANAMA CANAL"

MODULE A - HISTORY OF THE PANAMA CANAL

The American Society of Civil Engineers compiled a list of wonders of the modern world in 2010.

Wonder	Date started	Date finished	Location
Channel Tunnel	December 1, 1987	May 6, 1994	Strait of Dover, between the United Kingdom and France
CN Tower	February 6, 1973	June 26, 1976, tallest freestanding structure in the world 1976–2007.	Toronto, Ontario, Canada
Empire State Building	January 22, 1930	May 1, 1931, Tallest structure in the world 1931–1967. First building with 100+ stories.	New York, NY, U.S.
Golden Gate Bridge	January 5, 1933	May 27, 1937	Golden Gate Strait, north of San Francisco, California, U.S.
Itaipu Dam	January 1970	May 5, 1984	Paraná River, between Brazil and Paraguay
Delta Works/ Zuiderzee Works	1920	May 10, 1997	Netherlands
Panama Canal	**January 1, 1880**	**January 7, 1914**	**Isthmus of Panama**

The Panama Canal as it exists today is one of the modern wonders. Currently, this same water transit way is being expanded to carry more and larger ships from the West to the East or vice versa. The Panama Canal Expansion that is currently under construction supports the installation of the Third Set of Locks by its owner, the Panama Canal Authority (ACP) since the expansion project is adding one more set of larger locks adjacent to the existing and original two sets of locks. The current canal is configured with two side-by-side locks, allowing different ships to travel in opposite directions at the same time.

Conceptualization of the Canal

In 1513, Vasco Nunez de Balboa's discovery of the Pacific coast of Panama soon had merchants and empire-builders dreaming of a shortcut that would enable ships to sail westward from the Atlantic to the Pacific without making the arduous, 12,000-mile journey around the tip of South America.

Over the next two centuries, visionaries ranging from Benjamin Franklin to the German philosopher Goethe advocated the digging of a channel. After Latin America won independence from Spain in the 1820s, the revolutionary hero Simon Bolivar hired engineers to map a possible canal route. Some, such as German explorer Heinrich Alexander von Humboldt, argued that Panama was too wild and mountainous, and that Nicaragua would be a better location. U.S. Army Col. Charles Biddle, sent by President Andrew Jackson to Central America in 1835 to evaluate the matter, concluded after four days of hiking in the jungle that the impracticality of building a canal in Panama ought to be clear to anyone, "whether of common or uncommon sense." Nevertheless, over the next 40 years, a parade of speculators dreamed up canal-building schemes.

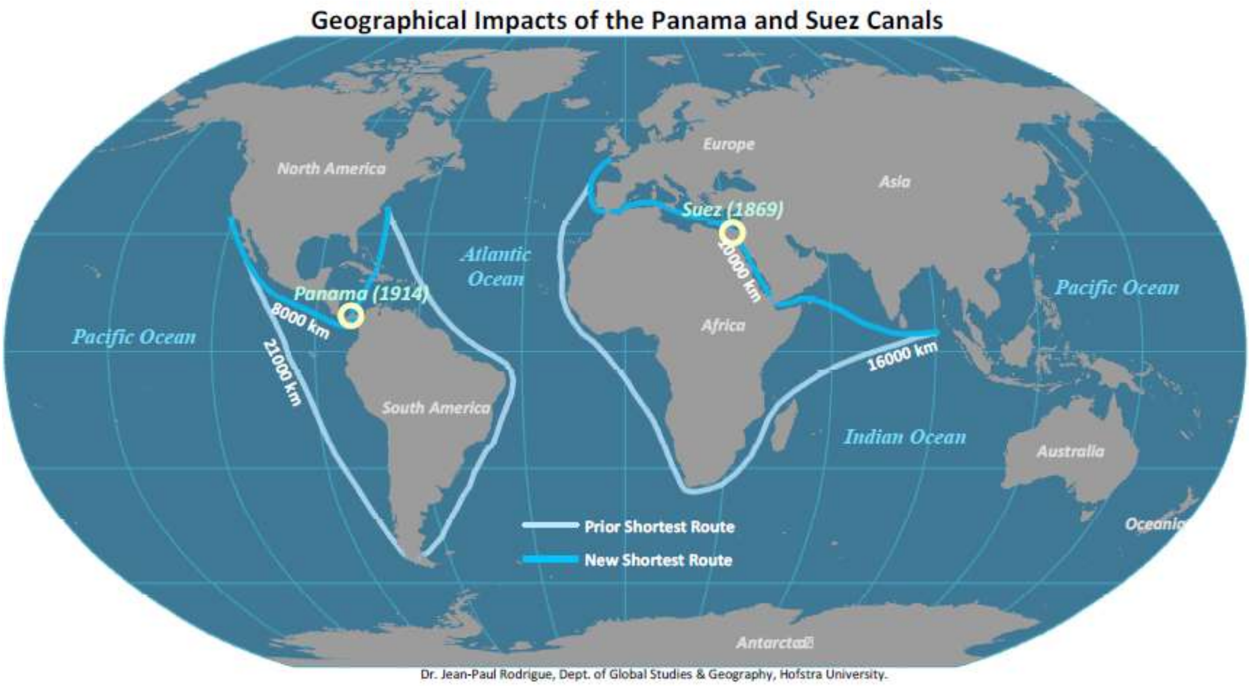
The discovery of gold in California in 1848 created a tremendous volume of trans isthmian business, mostly overland using the Panama Railroad as it was completed and came into use, and interest in a canal was heightened.

Panama vs. Other Locations

In 1869, President Grant ordered survey expeditions to Central America. The expeditions were organized by Navigation Bureau Chief Commodore Daniel Ammen and were under the command of the Secretary of the Navy. Surveys were conducted in Tehuantepec, Mexico, by Captain Robert W. Shufeldt; in the Darien by Commander Thomas Oliver Selfridge; in Nicaragua by Commander Chester Hatfield, Commander Edward P. Lull and Chief Civil Engineer Aniceto G. Menocal; and in Panama along the railroad line by Lull and Menocal. The fine quality of these surveys is still recognized today. Interestingly, the route of the current Panama Canal is nearly identical to that proposed by this Panama survey.

An Interoceanic Canal Commission was appointed by President Grant to evaluate the findings resulting from these Navy expeditions that took place between 1870 and 1875. A report was prepared by the Commission and, following due consideration, the Commission, in 1876, came out in favor of the Nicaragua route.

By this time, halfway across the globe, the Suez Canal had already been built and was operating. The Suez Canal, located in Egypt, is a 101 mile (163 km) long canal that connects the Mediterranean Sea with the Gulf of Suez, a northern branch of the Red Sea. Construction of the Suez Canal officially began on April 25, 1859. It opened ten years later on November 17, 1869 at a cost of $100 million. The Suez Canal was a sea-level canal build in a desert environment. The hero of that tremendous endeavor was Frenchmen Ferdinand de Lesseps.



The French Attempt

French diplomat and entrepreneur Ferdinand de Lesseps envisioned La Grande Tranchee ("the great trench") as a sea-level canal without locks, akin to the one built by the French at Suez. Unfortunately, the verdant jungles and mountainous terrain of Panama proved far-more difficult environments to conquer than the desert. Unfortunately, Lesseps was not an engineer, nor would he rely on the engineering studies that had been performed that recommended a lock canal. Besides the basis of design being flawed, the French encountered numerous operational problems including:

- (1881-1882) Contracted all of the work to Couvreux and Hersent, the Suez Canal builders, who later withdrew from the project due to various difficulties.
- (1883-1885) A number of small contractors performed the work under the direction of the Company.
- (1886-1887) Work was performed by a few large contractors.

- (1888-1889) Sea level canal approach abandoned and lock canal adopted.
- Disease was a big foe: By 1884, yellow fever was killing 200 laborers each month.
- Equipment was constantly being modified and used in experimental combinations, but mostly it was too light and too small.
- The spoil disposal system was inefficiently organized and managed, dump areas were too close to the excavation and slid back onto the channel whenever the rains came.
- Went through six Director Generals from 1881-1883, most of which suffered from disease.
- The Panama Railroad, for which $25 million was paid, had not been harnessed toward the effort of hauling spoil.
- Lowered the 312’ high Gaillard Cut by only 77’ to 235’ above sea level from 1881 to 1888.
- Ran out of money in 1888 at which time $235 million had been spent.

In 1890, after an investigation by the French Government into allegations of corruption and waste, it was determined that the value of the plant and work completed was $87.3 million having completed only two-fifths of the work. Consequently, De Lesseps and other were sentenced to five years in prison.

Statistics:

Number of snow shovels inexplicably ordered by the French:	10,000
Earth moved to date:	66,744,000 cubic yards
Total cost to date:	approximately $250 million
Number of lives lost during French control	20,000

MODULE B - ORIGINAL CANAL DESIGN AND CONSTRUCTION

The Geology of Panama

Every good design starts with a study of the geology of the project site. In the case of the Panama Canal the project sites runs through the entire country; hence the geology of Panama.

The Isthmus of Panama, only about 50 miles wide at its narrowest point, was characterized by mountains, impenetrable jungle, deep swamp, torrential rains, hot sun, debilitating humidity, pestilence and some of the most geologically complex land formations in the world. Most of this was apparent to the explorers and surveyors who explored and measured the land. What was not obvious was the geological makeup of the land, which is a constant challenge even today, one that is held at bay, but not yet conquered. Another thing that was apparent was that building a canal across Panama had already defied and defeated the technical expertise of one of the greatest nations on earth.

Low green mountains rising up behind coral shores look benign and inviting. However, unlike most mountain ranges, instead of being formed by folding due to lateral pressure, these mountains were formed by the upward thrust of individual volcanic actions. Independent formations of different types of hard rock are interspersed and layered between softer rocks and materials in a disorderly and unpredictable patchwork of strata and angles. The Isthmus has also been subjected to several periods of submersion beneath the sea, thus adding cavities of marine materials to the geological mix. This, in addition to there being six major faults and five major volcanic cores in just the short distance between Colon and Panama City adds to the area's geological challenges. Engineers of the time were unaware of this complex Isthmian geology, and perhaps fortunately so, for it might have frightened them off.

Flooding, especially of the Chagres River, was another very serious problem. Because of the terrain's precipitous slopes, the heavy rainfall gathers quickly into streamlets that flow quickly into the river, causing it to swell at a rapid rate, thus creating floods. What happens is nicely described in the official words of The Climatology and Hydrology of the Panama Canal:

"Although nearly the entire country, from its headwaters to Alhajuela, is clothed with vegetation, much of which is dense, the slopes are so precipitous, and the rock lies so near to the surface, that severe tropical rain storms convert the precipitous banks of the Chagres into a series of small torrents and cascades, causing the river to rise suddenly and discharge almost inconceivable volumes of water."

On July 19 and 20, 1903, for example, following two days of heavy rains, the Chagres River (normally some forty feet above sea level at Gamboa) rose to sixty feet above sea level, and its normal discharge rate of 3,000 cubic feet per second had increased to more than 31,000 cubic feet per second.

French engineers under de Lesseps had been unable to control the Chagres floods, and the American effort did not fully succeed either, until construction in the 1930s of the Madden (Alhajuela) Dam above Gamboa. The French had to periodically endure the disheartening wiping away by flood of bridges and equipment and the redepositing into the hard-won excavation of tens of thousands of tons of earth, rock and debris.

Finally, both malaria and yellow fever were endemic to the Isthmus. For several hundred years, outsiders came to this “Fever Coast,” especially seamen passing through, died from diseases purportedly caused by "miasmal mists" supposedly emanating from swamps and marshes.

"When the trade winds die out, and the hot sultry air of the isthmus ceases to move, a white mist will sometimes rise out of the swelling ocean and hover like a fog over land and sea. The white mist is the precursor of fever and sickness, and those of the isthmus who know remain within doors, unwilling to meet the ghost of the ocean half way. In the early days ... the white mist that rose from the disturbed soil of the isthmus was far more disastrous in its killing effects than the mists of the ocean. It rose from the soil like incense from a brazier. It carried with it from its underground prison all the poison of putrefaction, and wherever it enclosed its victims, there fever and death followed ..."

While it may seem ridiculous today, at the time there were no other, more credible, explanations. In fact, when it was ultimately proven that the bites of insects, namely mosquitoes, carried the dread diseases -- the Stegomyia fasciata for yellow fever and the Anopheles for malaria -- the idea was looked upon as equally preposterous, and proponents of such concepts were soundly ridiculed. Thus was the state of medical knowledge of the period.

The American Attempt

The U.S. Isthmian Canal Commission of 1899-1901, following failure of the French canal effort, ordered to again study all routes feasible to constructing a water route between the Atlantic and Pacific oceans. The study was ordered by U.S. President William McKinley, who succeeded Grant in office. This time, the Panama and

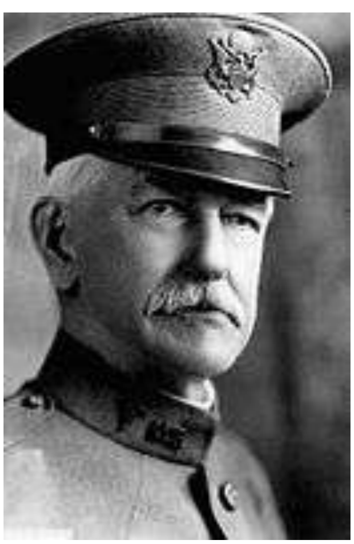
Nicaragua routes were to receive special consideration. The Nicaragua route again came out as the favored choice, but not for long.

In 1898, with the United States and Spain on the brink of war, the Oregon -- the U.S. Navy's first true battleship -- took 67 days to rush back from San Francisco to the Caribbean. That stuck in the mind of Theodore Roosevelt. When William McKinley's assassination made Theodore Roosevelt president in 1901, he vowed to build a canal -- not for commerce, like the French, but to ensure that U.S. naval power could dominate two oceans. He favored Nicaragua at first but abruptly changed his mind to Colombian owned Panama when the French made it known they were willing to unload their partly dug ditch at a bargain price of $40 million. At the last moment, Colombia nearly threw a wrench in the deal by insisting that the United States pay for the right to dig on Colombian soil, but the White House and the Panama Canal lobby were not to be stopped. In late 1903, revolutionaries organized and financed by Bunau-Varilla staged a coup on the Isthmus, and a U.S. warship suddenly steamed into Panama City's harbor to deter the Colombians from suppressing the revolt. The new, independent nation of Panama quickly gave the United States the go-ahead. The Americans, however, could only use a portion of what the French had excavated. Over 48,000,000 cubic yards of earth moved through French back-breaking labor was useless as the Americans began to dig.

Statistics:

Number of persons killed in the Panamanian revolution:	1 (also 1 donkey)
Useful excavation to date:	29,700,000 cubic yards
Total cost to date:	approximately $337 million

In 1905, workers on the American canal project began to fall ill with yellow fever, the deadly disease that had decimated the French work force 20 years before. But the Americans, unlike the French, had a way to fight the disease.



In 1900, U.S. Army tropical disease expert Walter Reed proved what previous scientists had suspected -- that the fever was transmitted not by poor sanitation or contact with infected people, but by the female member of the mosquito species Stegomyia fasciata. The following year, in fever-ridden Havana, a Reed protégé named Col. William C. Gorgas staged a successful campaign to eradicate the mosquitoes; yellow fever disappeared. Gorgas was assigned to Panama but ran into stiff resistance at first from budget-conscious bureaucrats who thought, incredibly, that he wanted tons of old newspapers, which he needed to seal windows for fumigating, as reading material for fever patients. Finally, in April 1905, after the fever outbreak had killed 47 workers, Gorgas got the go-ahead and funding he needed. Over the next few months, he installed $90,000 worth of wire screens on windows and sent teams of health workers on a door-to-door search for mosquitoes and their eggs. They fumigated houses -- several times if necessary – and enforced a ban on the old Panamanian custom of keeping water indoors in uncovered containers. They traced the movements of victims to determine where they'd been infected. By December, yellow fever had vanished from the Canal Zone.

The American canal builders started out almost as badly as the French: the first wave of laborers had to drive railroad spikes with axes because they hadn't been given sledgehammers. The Roosevelt administration appointed the illustrious John Findley Wallace as head engineer. This former president of the American Society of Civil Engineers was accustomed to building low-stress projects in urban areas, and he left after just a year to take a job in the private sector. His successor, John Stevens, lacked a college degree, but he was a rough-hewn outdoorsman who'd extended the Great Northern Railroad through the Rockies, using a mountain pass he himself had discovered. Stevens stopped digging and spent two years methodically building the infrastructure needed to stage the massive project -- everything from sewers for Panama's two cities to a bakery to supply his workers with bread. By early 1907, when Stevens was ready to resume digging, the effort was so well-organized that before long the workers were excavating 500,000 cubic yards of soil per month; more than double the French's best performance. Stevens astutely realized that a sea-level canal would be too difficult, and convinced Roosevelt to opt for a canal with locks instead.

Statistics:

Earth moved to date:	46,000,000 cubic yards
Total cost to date:	approximately $437 million

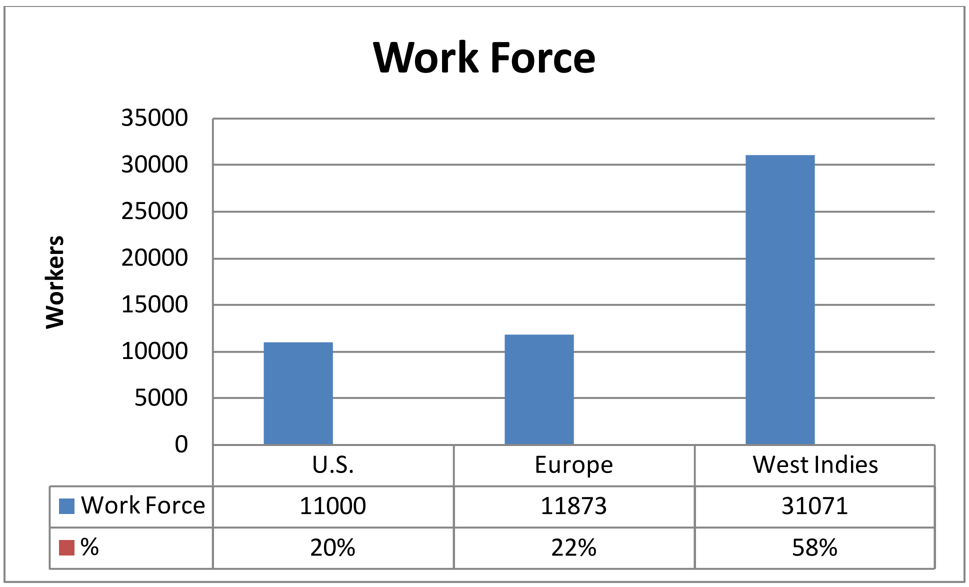
In 1907, chief engineer Stevens resigned for personal reasons and Roosevelt quickly replaced him with Army officer Col. George W. Goethals, who led the project through to its completion. Goethals took the efficient system that Stevens had built and pushed it to ever-astonishing levels of performance. From 1907 to 1914, Goethals' work force excavated nearly 215,000,000 cubic yards of earth, over three times what the French had accomplished. Goethals also supervised the construction of the locks advocated by Stevens, the biggest and most technologically advanced devices of their kind ever built. In August 1914, a cement boat, the Cristobal, made the first actual passage from the Atlantic to the Pacific, with Philippe Bunau-Varilla onboard. Two weeks later, on August 15, a ship named Ancon sailed on the first official interocean transit through the Panama Canal.

Statistics:

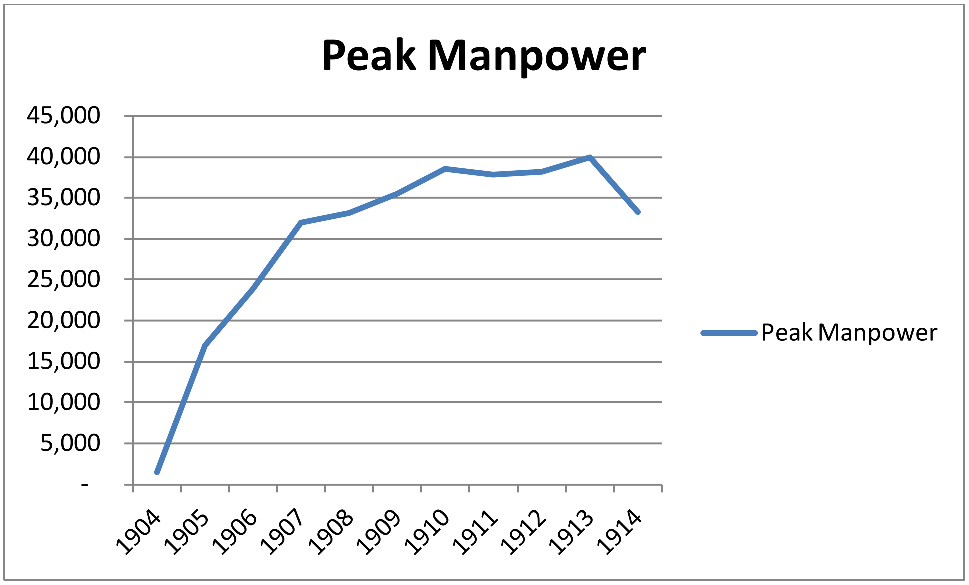
Estimated height of earth excavated if it were piled:	one city block wide by 19 miles high
Earth moved to date:	262,000,000 cubic yards
Total cost to date (1913):	approximately $639 million
Equivalent cost (2013):	Approximately $14.8 billion

Work Force

Unlike the French work force which consisted of 90% foreign workers from the West Indies, the American work force was a mixture of West Indian, European, and American workers.



The peak manpower employed by the French was 20,000 men in 1888. Peak manpower for the American project reached 39,962 direct hire people working in 1913 plus another 5,000 working for McClintic-Marshall Company, the only contractor hired to build the lock gates. This excludes an additional 20% that were either sick or on leave.


Peak Manpower
45,000
40,000
35,000
30,000
25,000
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1904
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1912
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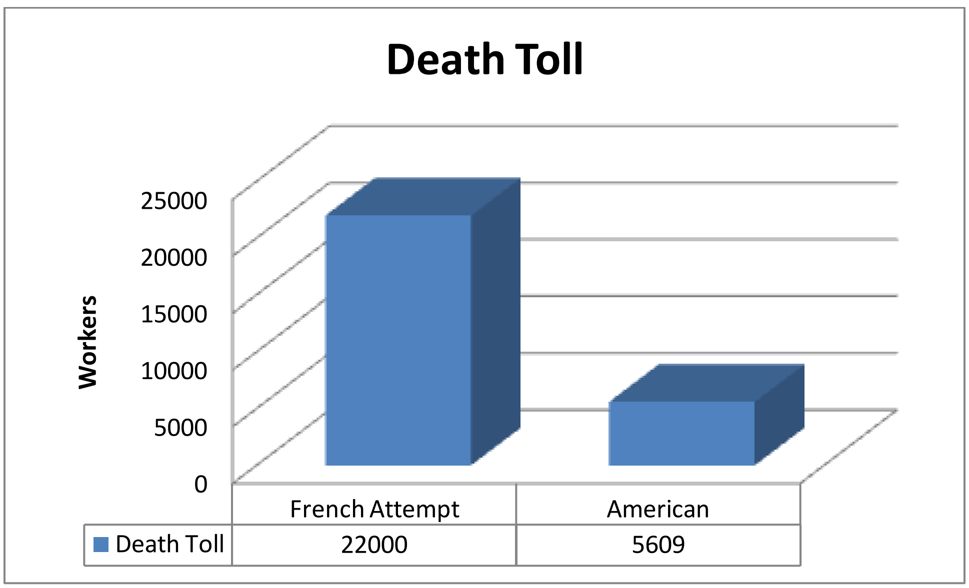
1914
Peak Manpower


Death Toll
Workers
25000
20000
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5000
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French Attempt
American
Death Toll
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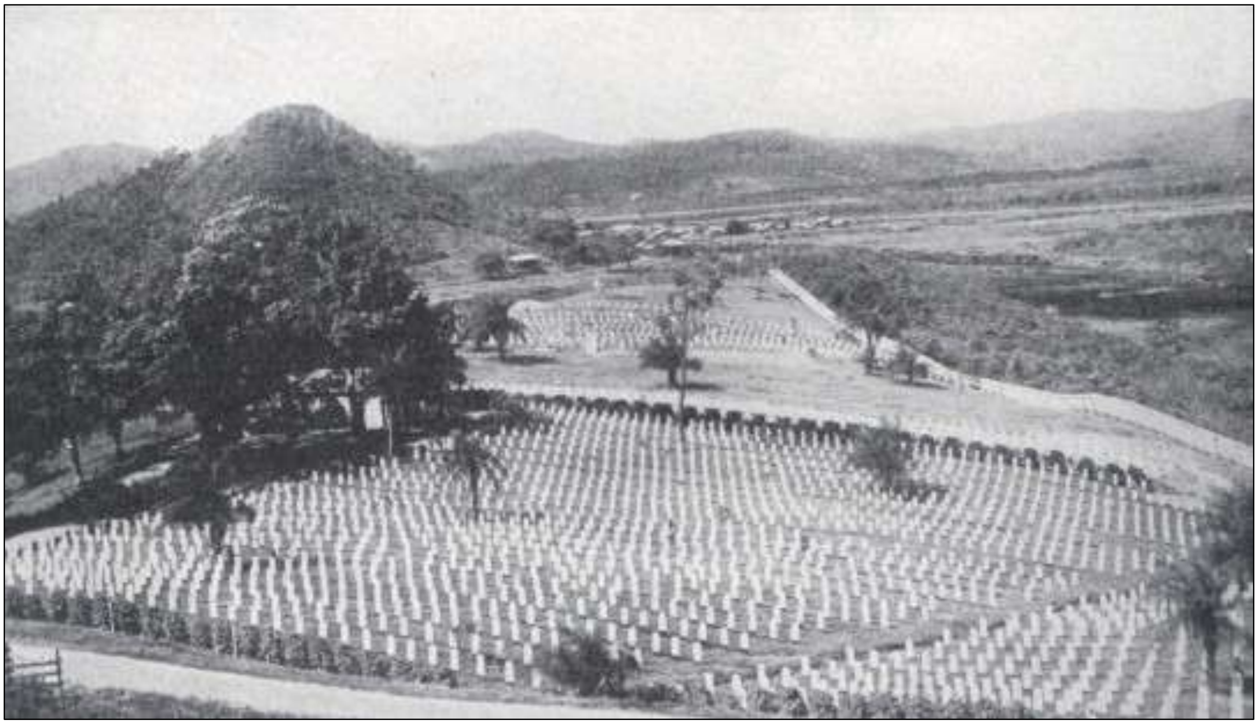
5609



Whole communities, including housing, mess halls, hospitals, hotels, schools churches, cold storage, clubhouses and laundries were built to accommodate them. Streets were paved in Colon and Panama City and water and sewage systems installed. At one time, nearly half of the 24 thousand-man work force was employed at constructing buildings.

Providing food for more than 40,000 employees and their families in a country with little food production capability and few stores was a tremendous task at the beginning. With the goal in mind of maintaining a healthy and contented work force, the Isthmian Canal Commission imported food on the Panama Railroad steamers. They also started farms to grow fruits and vegetables, even plants and flowers, as well as farms to produce milk and eggs.

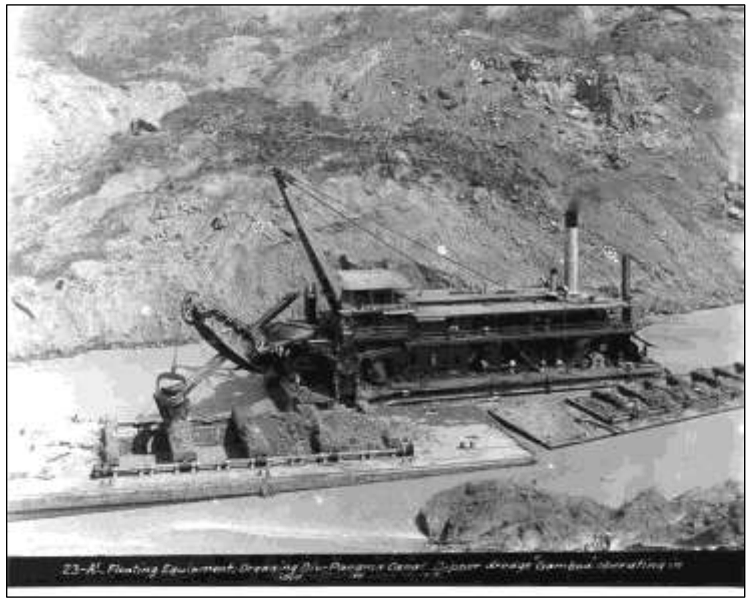
It was a difficult task in the beginning, but every effort was made to ensure adequate living standards, in accordance with standards of the time, for canal workers. Ice and cold storage warehouses were constructed, and a bakery and ice cream plant were set up. The Panama Railroad had refrigerated cars to provide distribution to settlements along the line of the canal.

Construction Innovation

Stevens developed the ingenious system of Canal excavation and disposal of rock and soil, called "spoil." He devised a complex but very workable and efficient system of railroad tracks at different levels within the Cut. Spoil train schedules were coordinated to the level where the excavation work was being done. Spoil train capacity kept pace with the excavation work, keeping both trains and steam shovels efficiently employed at all times.

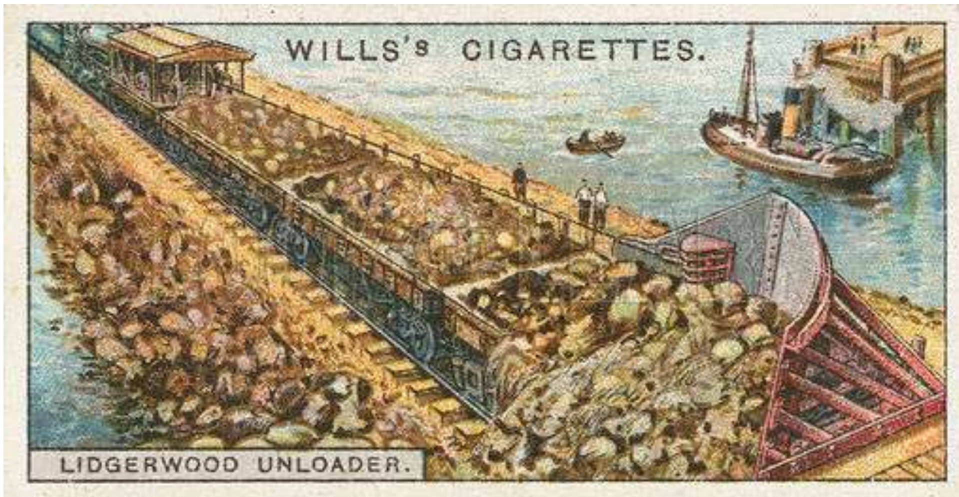
Col. George Washington Goethals, who succeeded Stevens as chief engineer during the construction period and under whose leadership the Canal was completed, would say: "Stevens devised, designed, and made provision for practically every contingency connected with the construction and subsequent operation of the stupendous project... It is therefore to him, much more than to me, that justly belongs the honor of being the actual 'Genius of the Panama Canal...'"

The steam shovel became the workhorse both for excavation and dredging. The Bucyrus-Erie Shovel Company supplies 77 steam shovels (left) and the 15 CY Gamboa dipper dredge (right below) capable of dredging 15,145 CY in 24 hours.



The Marion Steam Shovel Company supplied 25 steam shovels for excavation work on the canal.

The Lidgerwood unloader, manufactured by the Lidgerwood Manufacturing Company of New York City, was another indispensable piece of equipment. Wooden flatcars with a rated canal capacity of 19 cubic yards hauled most of the spoil, pulled in long trains by full-sized, American built locomotives. Built with only one side, they had steel aprons bridging the spaces between cars. Dirt was piled high against one side. At the dump site, the unloader, a three-ton plow, was hitched to the last car by a long cable to a huge winch-like device mounted on a flatcar at the head of the train. Taking its power from the locomotive, the winch pulled the plow rapidly forward, unloading the whole twenty-car train in a single, 10-minute sweep. One of these machines once set an 8-hour record by unloading 18 trains, about 3 ½ miles of cars containing about 7,560 cubic yards of material. Engineers estimated that 20 of these unloaders operated by 120 laborers did the work of 5,666 men unloading by hand.



The dirt-spreader was another American innovation. A car operated by compressed air, it had steel "wings" on each side that could be raised and lowered. When lowered, they sloped 11.5 feet backward from the rails. Moving forward, the dirt-spreader spread and leveled the material left along the track by the unloader. Like the unloader, the spreader did the work of some 5,000 to 6,000 men working by hand

Another machine, the track-shifter, was invented by American William G. Bierd, general manager of the Panama Railroad from September 1905 to October 1907. The huge crane-like machine would hoist a whole section of track – rails and ties – and swing it in either direction, to relocate it as much as 9 feet at a time. With the tracks at the dumps needing constant shifting to keep pace with the arriving loads of spoil, the track-shifter was extremely useful. It took less than a dozen men operating on the shifter one day to move a mile of track, a task requiring not less than 600 men.

DESIGN OF THE LOCKS

The original lock canal plan called for one three-step set of locks at Gatun, one step at Pedro Miguel and a two-step set at Sosa Hill. In late 1907, it was decided to move the Sosa Hill locks further inland to Miraflores, mostly because the new site provided a more stable construction foundation, but also because it afforded greater protection against sea bombardment.

The locks took their names from geographic names already in common use before the Canal was built. All lock chambers have the same 110 by 1,000 feet dimensions, and they are built in pairs. That is, two lanes of chambers run side by side to accommodate two lanes of traffic, either in opposite directions at the same time or in the same direction, depending on transit needs. Gatun Locks consists of three steps or pairs of chambers, there is one step at Pedro Miguel and two at Miraflores, making six pairs, 12 chambers in all. The locks have been called the structural triumph of the Panama Canal and are a unique aspect of the waterway. At the time of their construction, their overall mass, dimensions and innovative design surpassed any similar existing structures, and they are still considered to be an engineering wonder of the world.

It took four years to build all of the locks from the first concrete being laid at Gatun on August 24, 1909. Until the late 1800s, concrete, a combination of sand, gravel and cement, had been little used in building, and then mostly for floors and basements. There was still a great deal to be learned and numerous decisions to be made in the science of concrete which requires specific, controlled measurements of water/cement/sand ratios and aggregate size, as well as careful timing of a streamlined delivery system from source to site. The concrete work in Panama was an unprecedented challenge that would not be equaled in total volume until construction of Boulder Dam in the 1930s.

In spite of the newness of the science, the results were extraordinary. After more than 80 years of service, the concrete of the Panama Canal locks and spillways is in near perfect condition, which to present-day engineers is among the most exceptional aspects of the entire Canal.

Canal organization ships, the Ancon and the Cristobal, brought all of the cement to build the locks, dams and spillways from New York. On the Atlantic side, gravel and sand came by water from areas east of Colon, the gravel from a large crushing plant in Portobelo and the sand from Nombre de Dios. For the Pacific side, rock was quarried and crushed at Ancon Hill; the sand came from Punta Chame in Panama Bay.

Three men, Lieutenant Colonel Harry Hodges, Edward Schildhauer and Henry Goldmark, were largely responsible for the engineering design of the locks. The work took years of advanced planning. Hodges was an Army officer and an invaluable assistant to Goethals, had overall responsibility for the design and construction of the lock gates, arguably the most difficult technical responsibility of the entire project. Goethals was to state that the Canal could not have been built without Hodges. Schildhauer was an electrical engineer and Goldmark was in charge of lock gate design.

The key factor in the whole Canal enterprise, of course, was, and is, water. Water lifts ships 85 feet above sea level to the surface of Gatun Lake, floats them across the Continental Divide and lowers them again to sea level in the opposite ocean. Water also serves to generate electrical power for the Canal to run the electric motors that open and close the gates and valves and the electric locks locomotives.

No pumps are used at the Panama Canal, the water does its work by force of gravity alone. Water is admitted or released through giant tunnels, or culverts, eighteen feet in diameter, running lengthwise within the center and side walls of the locks. Branching off at right angles to these culverts, smaller culverts run laterally under the floor of each lock chamber, 20 to each chamber. Each cross culvert has five openings for a total of 100 holes in each chamber for the water to enter or drain, depending on which valves are opened or closed. This large number of holes distributes the water evenly over the full floor area to control turbulence.

To fill a lock, the main valves at the lower end of the chamber are closed, while those at the upper end are opened. The water pours from the lake through the large culverts into the cross culverts and up through the holes in the chamber floor. To release the water from the lock, the valves at the upper end are closed, while those at the lower end are opened.

The lock gates, or miter gates as they are known because they close in a wide V, are the Canal’s most dramatic moving parts. The gates swing like double doors. The hollow, watertight construction of their lower halves makes them buoyant in the water, greatly reducing the working load on their hinges. All gate leaves are 64 feet wide by 7 feet thick. However, they vary in height from 47 to 82 feet, depending on their position. For example, the Miraflores Locks lower chamber gates are the highest because of the extreme variation in the Pacific tides.

The design and manufacture of all of the lock gates was one of the Canal’s great engineering challenges and one of its greatest triumphs. The simple, yet powerful gate operating mechanism was designed by Edward Schildhauer. In its design he had no established model to go by. Yet every aspect of this critical mechanism had to be precision engineered and manufactured to work flawlessly and dependably. The gates had to swing easily, yet withstand enormous pressures. To operate, the lock gates leaves are connected by steel arms, called “struts,” to huge bull wheels constructed within the lock walls. Each 20-foot-diameter, horizontal-lying bull wheel is geared to an electric motor. When in operation, wheel and strut work like the driving wheel and connecting rod on a railroad locomotive to open and close the gates.

At Miraflores Locks, each lock chamber, except for the lower locks, has a set of intermediate gates. The purpose of these is to conserve water by reducing the size of the chamber, if the ship in transit is not one of the Panamax giants and be accommodated by a 600-foot chamber.

As the lock gates themselves are a form of dam and above sea level, precautions were taken to protect them from damage that could allow the lake water to escape and flow out to sea. One measure was to have double gates ahead of the vessel, an operating gate and a guard gate, at points where damage to a gate could join the two levels, that is, at the upper and lower ends of the upper lock in each flight and at both ends of the Pedro Miguel single-step lock.

Also, iron fender chains were installed to stretch across the chambers between the lock walls to protect the guard gates. Only after the ship was in proper position and under towing locomotive control was the chain lowered. The idea was that if a ship went out of control and struck the chain, an automatic release would let the chain out slowly until the ship came to a stop, thus limiting possible damage. The expense of their upkeep against the extreme unlikelihood of their use caused the Board of Directors to approve fender chain removal in July 1976, except at the upper ends of Gatun and Pedro Miguel locks; these remaining chains were removed in October 1980.

Yet another devise stood as safeguard should a ship break through a guard gate. That was what was called an emergency dam installed on the side walls at the entrance of each upper lock between the fender chain and the guard gates. It a big steel apparatus mounted to swing across the lock entrance in about two minutes in case of emergency. A series of wicket girders would descend forming runways down which huge steel plates would be dropped until the channel was sealed off. Never put to use, the emergency dams were removed in the mid-1950s.

Electricity was the power that ran Canal construction-era cableways, cranes, rock crushers and cement mixers. An all-electric canal was an innovation in the first decade of the 20th century. Locks operations required some 1,500 electric motors, as all controls were electrical. The General Electric Company produced about half the electrical equipment needed during construction and virtually all of the permanent motors, relays, switches, wiring and generating equipment. They also built the original locks towing locomotives and all of the lighting.

The electric towing locomotive system was designed to provide complete control over the movement of vessels transiting the locks. Designed by Schildhauer, the locomotives work on track built atop the lock walls operating at a speed of about 2 miles per hour. An important design factor was that they have to travel the 45-degree incline between the lock chambers. The locomotives were built in Schenectady, New York, at a unit cost of $13,000.

Schildhauer also designed the basic concept of the locks control system, though its development was a joint effort with General Electric. All locks operation is accomplished from a control house built on the center wall of the upper lock chamber. Here, from an unobstructed view of the entire locks flight and a cleverly designed control board, a single person can run every operation in the passage of a ship, except towing locomotive movement.

A control board is a waist-high working representation of the locks in miniature. Everything that happens in the locks happens on the control board at precisely the same time. The switches to work the lock gates and the other system mechanisms are located beside the representation of that devise on the control board. To lift a huge oceangoing ship in a lock chamber, the operator has only to turn a small chrome handle.

Another ingenious part of the system are elaborate racks of interlocking bars installed unseen below the control board to make the switches mechanically interlock. Each handle must be turned in proper sequence or it will not turn. This eliminates the possibility of doing anything out of order or forgetting a step.

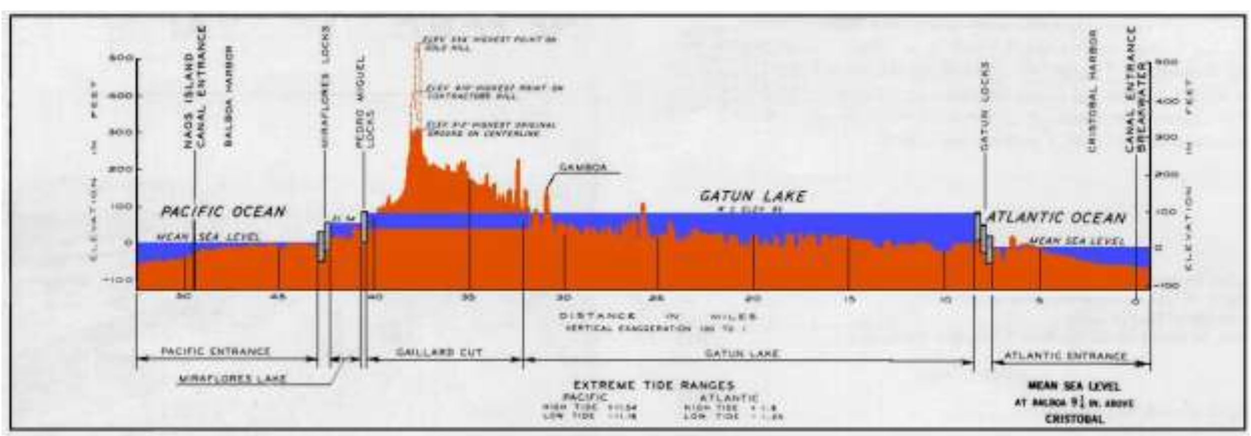
Only in an electrically run system could the locks have been controlled from a central point. An individual motor in the system can be located as much as half a mile away from the control board. This same system has been in use virtually unchanged for more than eight decades, and it still works perfectly.

The Pacific-side locks were finished first, the single flight at Pedro Miguel second in 1911 and Miraflores in May of 1913. Exceptionally high morale permeated the entire work force at this time. On May 20, 1913, shovels No. 222 and No. 230, which had been slowly narrowing the gap in Culebra Cut, met “on the bottom of the Canal.” At 40 feet above sea level, the Cut had reached its full construction-era depth. Guard gates at Gatun performed flawlessly the second week of June 1913, and on June 27, the last of the Gatun Dam spillway gates was closed, allowing the lake to now rise to full height. Dry excavation ended three months later. When a January 1913 slide at Cucaracha spilled 2,000,000 cubic yards of earth into the Cut, it was decided to flood the Cut and finish the clearing by dredge. The last steam shovel lifted the last rock in the cut on the morning of September 10, 1913, to be hauled out on the last dirt train by locomotive No. 260.

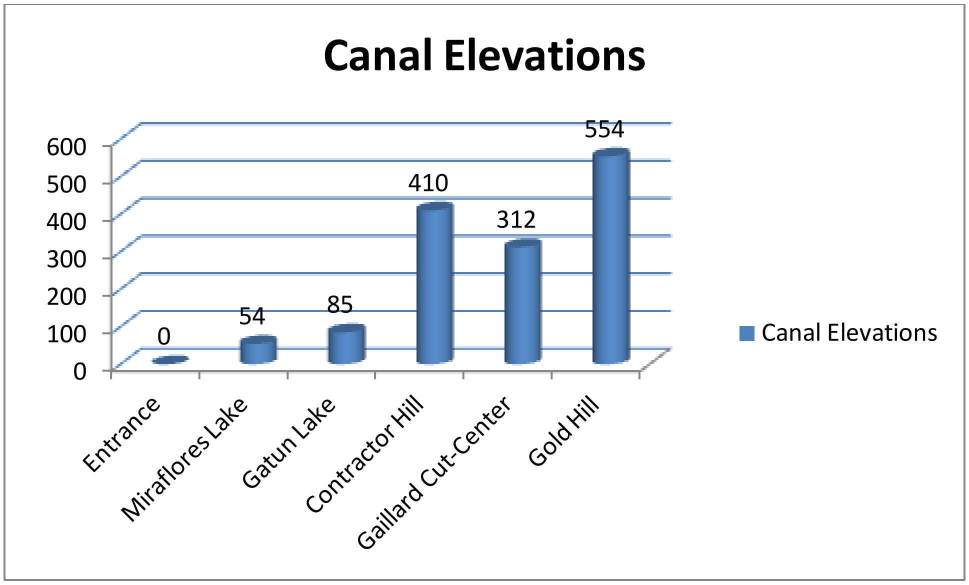
The seagoing tug Gatun, an Atlantic entrance working tug used for hauling barges, had the honor on September 26, 1913, of making the first trial lockage of Gatun Locks. The lockage went perfectly, although all valves were controlled manually since the central control board was still not ready.

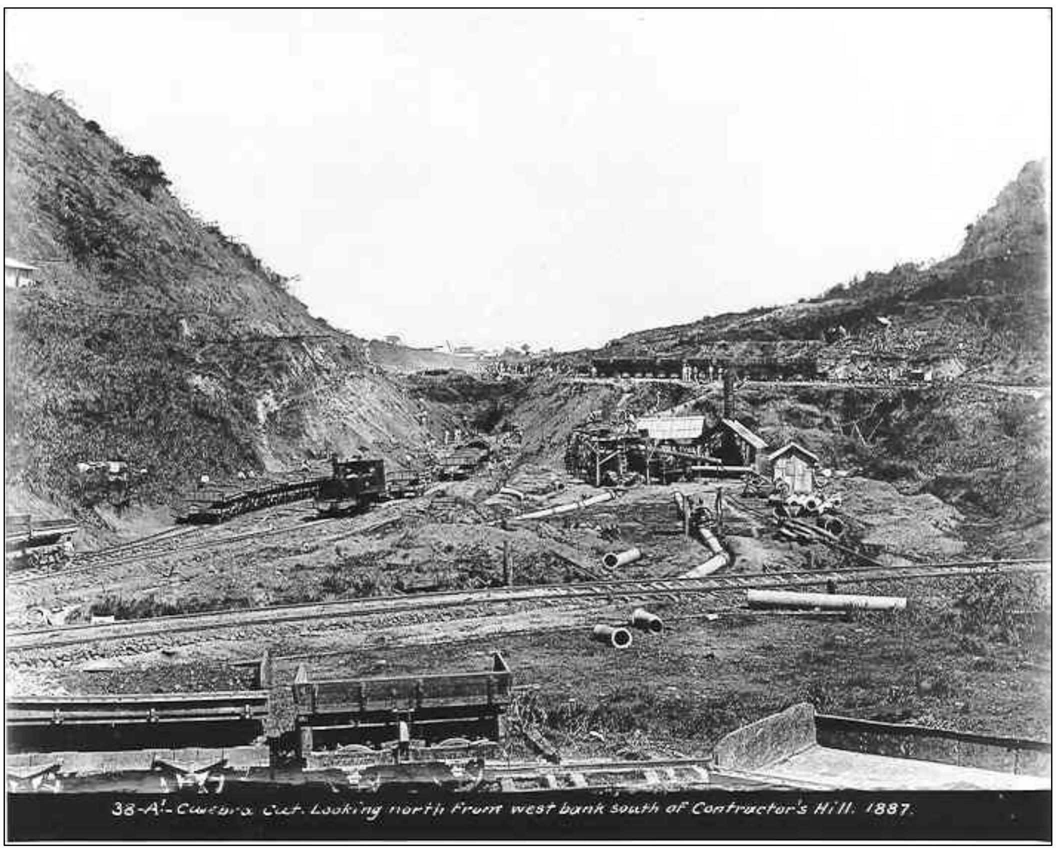
As if to further test the system, an earthquake struck on September 30, knocking seismograph needles off the scale at Ancon. Although there were landslides in the interior and cracked walls in some Panama City buildings, Gorgas reported to Washington that "There has been no damage whatever to any part of the Canal."

Six big pipes in the earthen dike at Gamboa flooded Culebra Cut that same week. Then, on October 10, 1913, President Woodrow Wilson pressed a button in Washington and relayed by telegraph from Washington to New York to Galveston to Panama the signal that blew the center of the dike to complete the flooding of the Cut and join it to Gatun Lake.



PROFILE OF THE PANAMA CANAL


Canal Elevations
600
500
400
300
200
100
0
0
54
85
410
312
554
Entrance
Miraflores Lake
Gatun Lake
Contractor Hill
Gaillard Cut-Center
Gold Hill
Canal Elevations

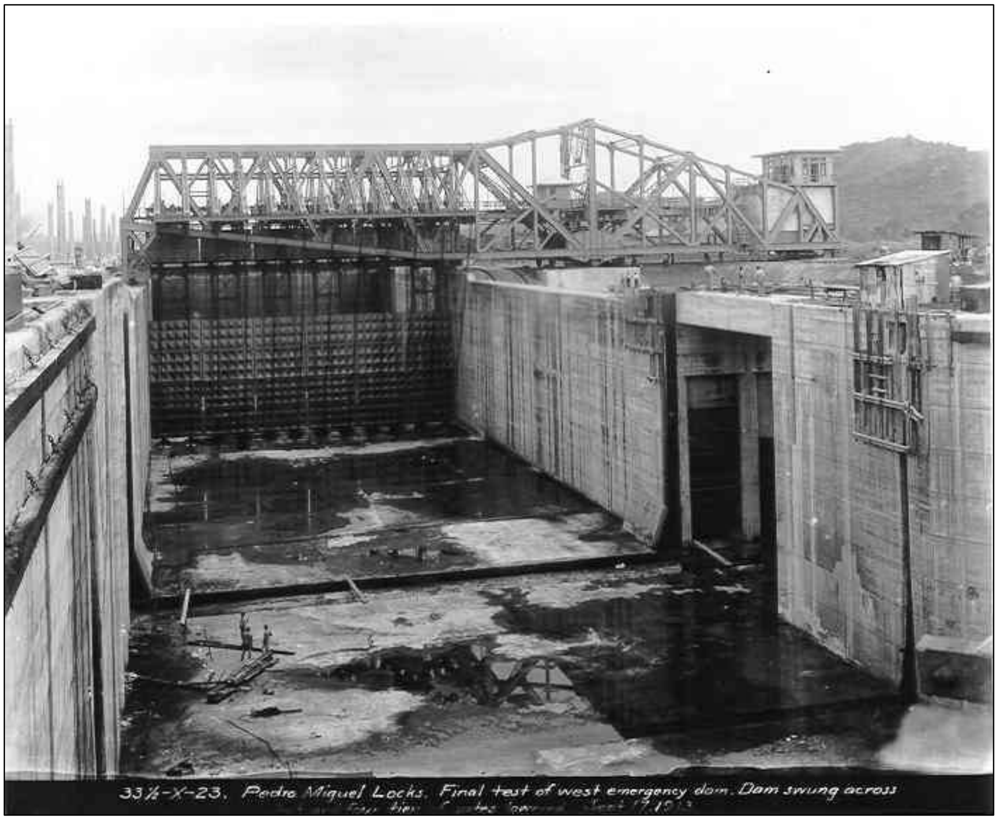

38-A¹-Culebra Cut. Looking north from west bank south of Contractor's Hill. 1887.

3-A4 Culebra Cut. Culebra. Steam shovel excavating and loading French dump cars near Gold Hill. Looking south. Dec. 1904.

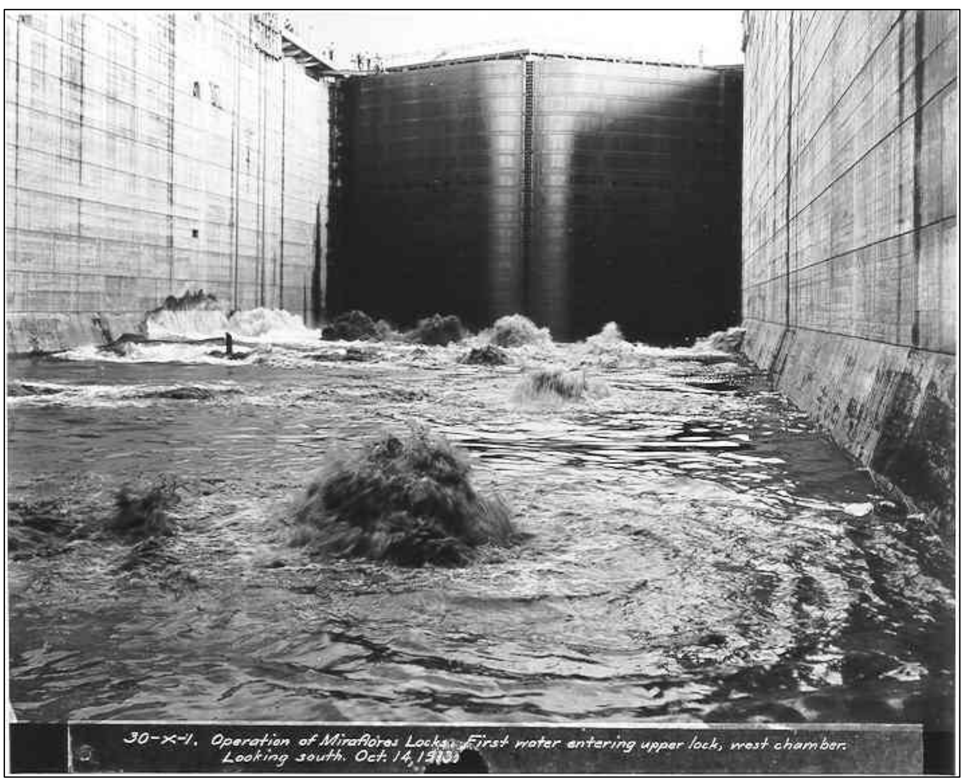
31. – Culebra Cut. Culebra. View looking north from a point corresponding to present Station 1772 – July 17, 1905.

38-L. – Culebra Cut. Looking North, between Contractor's Hill and Gold Hill. – June, 1911.

3 X! – Culebra Cut. Culebra looking South between Gold Hill and Contractors Hill. The cut [illegible] Dec 25 1912



33½-X-23. Pedro Miquel Locks. Final test of west emergency dam. Dam swung across ... Sept 17, 1913



30-X-1. Operation of Miraflores Locks. First water entering upper lock, west chamber. Looking south. Oct. 14, 1913.

The Panama Canal Administration Building, the former seat of the Canal Zone Government and Panama Canal Company, is located in Balboa Heights and continues to perform its duties as the main administration building for the agency that runs the Panama Canal—previously the Panama Canal Commission, now the Panama Canal Authority.

Modern day view of ACP Administration Building

The following comes from a plaque in the rotunda of the Panama Canal Administration building –

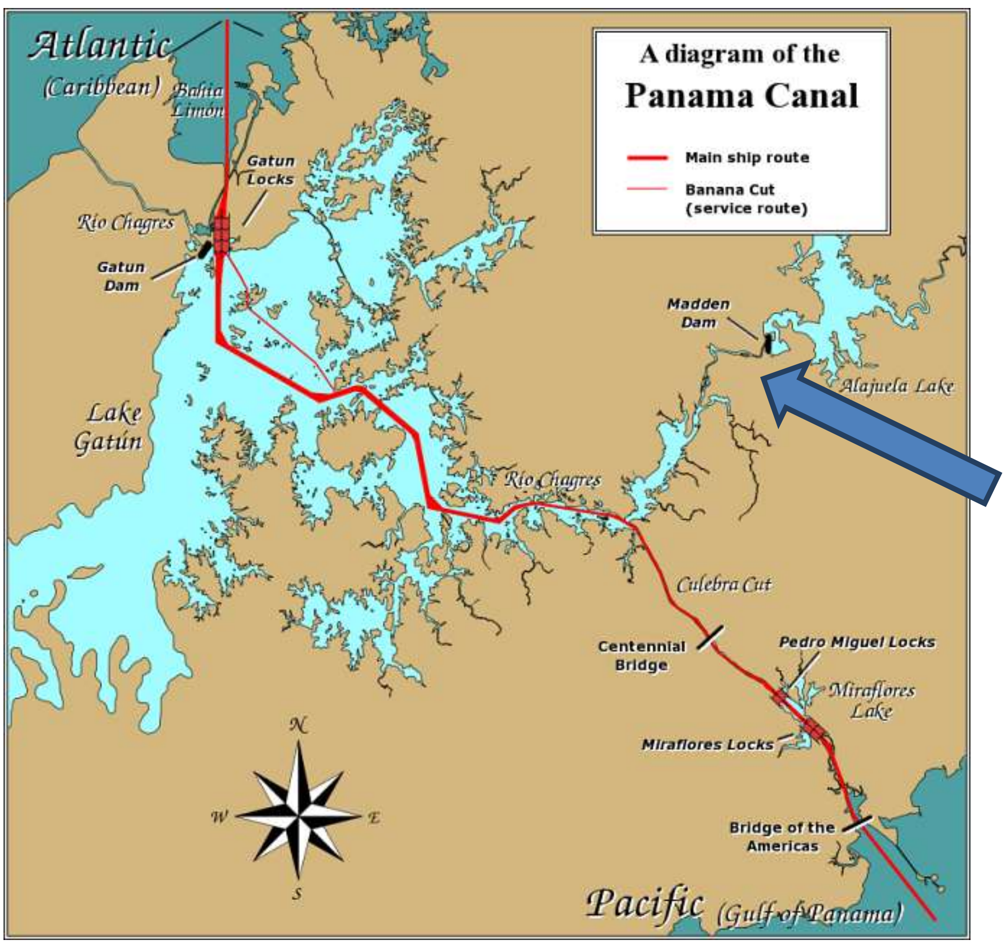
"It is not the critic who counts, nor the man who points out how the strong man stumbled, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena; whose face is marred by dust and sweat and blood; who strives valiantly, who errs and comes short again and again; who knows the great enthusiasms, the great devotions, and spends himself in a worthy cause; who, at the best, knows in the end the triumph of high achievement; and who at the worst, if he fails, at least fails while daring greatly, so that his place shall never be with those cold and timid souls who know neither victory nor defeat." Theodore Roosevelt

MODULE C – CANAL UPGRADES

Although the original canal is currently very functional today, there have been several improvements and upgrades made over the past century. These include improved water management and an attempt at adding a third set of locks as well as periodic dredging along the navigational waterway to maintain and increase its depth.

Madden Dam

When the canal operations began in 1914, it became evident that, for water management purposes, another dam was needed. It had to be above Gatun Lake. On October 13, 1931 construction on another dam was begun up the Chagres River near the location of a little town called Alajuela. The dam was named Madden, after U.S. Congressman Martin B. Madden, Chair of the House Appropriations Committee, who played an important role in support of the project. The dam would not only help control the tremendous floods of the Chagres, but also hold water in reserve for periods when traffic through the canal was at its highest point. And additional benefit was the hydroelectric power it generated for use in the operation of the canal.



Madden Dam is located 250 feet above sea level and retains 29 million cubic feet of water. It was constructed by the engineering companies of W.E. Callahan and Peterson, Shirley & Gunther of Omaha for $4,047,407 which was a lot less than had been estimated by the Isthmian Canal Commission. The dam was completed in 1935.

The upper Chagres River and its seven tributaries flow into Lake Alajuela, the reservoir created by the Madden Dam. As these rivers contribute 45 percent of the total water for the canal, the lake is an essential part of the watershed of the canal zone. The lake can store one third of the canal's annual water requirements for the operation of the locks. Unlike Gatun Lake, Lake Alajuela is not part of the navigational route, so there are fewer restrictions on its water level. Water from the reservoir is also used to generate hydroelectric power and to supply Panama City's fresh water.

First Attempt-Third Set of Locks

On August 11, 1939, Congress authorized the immediate construction of an additional set of locks, the third locks. Each chamber was to be 1,200 feet long and 135 feet wide. They were to be located about half a mile east of the original flight in Gatun. Gatun was to become an island between the two sets of locks and was in for some of the greatest boom days of its up-and-down history. An official estimate of the force to be required set a peak of over 9,000 workers by 1943. The third locks on the Pacific Side were to be adjacent to Miraflores Locks on the west side.

In January 1941, the contracting firm of Wunderlich & Okes signed a contract for the excavation and construction men moved in. In the bottom of the third locks cut, now a great, gaping hole, giant shovels dumped their loads into dozens of trucks which raced about on the right-hand side of the imaginary highways below, and then, when they reached the top, switched over to the left-hand drive and sedate speed limits of those days. From an observation platform, which still stands at the end of High Street, anyone could watch the ordered turmoil below.

A few months after Pearl Harbor, Samuel Rosoff of New York, won the $45,705,000 contract to build the new Locks. Wunderlich & Okes completed their contract in May 1943, but the Rosoff contract was canceled. Shipping had been diverted to the war areas, cement and steel were all but unobtainable and there was a military difference of opinion on the strategic value of the third locks. The project was cancelled and never completed.

Efficiency and Maintenance

Opponents to the 1977 Torrijos-Carter Treaties feared that efficiency and maintenance would suffer following the U.S. withdrawal from the Panama Canal Zone; however, this does not appear to have been the case. Capitalizing on practices developed during the American administration, canal operations are improving under Panamanian control. Canal Waters Time (CWT), the average time it takes a vessel to navigate the canal, including waiting time, is a key measure of efficiency; according to the ACP, since 2000, it has ranged between 20 and 30 hours. The accident rate has also not changed appreciably in the past decade, varying between 10 and 30 accidents each year across approximately 14,000 total annual transits. An official accident is one in which a formal investigation is requested and conducted.

Increasing volumes of imports from Asia, which previously landed on U.S. West Coast ports, are now passing through the canal to the American East Coast. The total number of ocean-going transits increased from 11,725 in 2003 to 13,233 in 2007, falling to 12,855 in 2009. (The canal's fiscal year runs from October through September.) This has been coupled with a steady rise in average ship size and in the numbers of Panamax vessels passing through the canal, so that the total tonnage carried rose from 227.9 million PC/UMS tons in fiscal year 1999 to a record high of 312.9 million tons in 2007, falling to 299.1 million tons in 2009. Despite the reduction in total transits due to the Panama Canal negative impact of vessel size (e.g., the inability of large vessels to pass each other in the Gaillard Cut), this represents significant overall growth in canal capacity.

The Panama Canal Authority (ACP) has invested nearly US$1 billion in widening and modernizing the canal, with the aim of increasing capacity by 20%. The ACP cites a number of major improvements, including the widening and straightening of the Gaillard Cut to reduce restrictions on passing vessels, the deepening of the navigational channel in Gatun Lake to reduce draft restrictions and improve water supply, and the deepening of the Atlantic and Pacific entrances to the canal. This is supported by new equipment, such as a new drill barge and suction dredger, and an increase of the tug boat fleet by 20%. In addition, improvements have been made to the canal's operating machinery, including an increased and improved tug locomotive fleet, the replacement of more than 16 km (10 mi) of locomotive track, and new lock machinery controls. Improvements have been made to the traffic management system to allow more efficient control over ships in the canal. In December 2010, record-breaking rains caused a 17-hour closure of the canal; this was the first closure since the United States invasion of Panama in 1989. The rains also caused an access road to the Centenario bridge to collapse.

The canal is currently handling more vessel traffic than had ever been envisioned by its builders. In 1934 it was estimated that the maximum capacity of the canal would be around 80 million tons per year; as noted above, canal traffic in 2009 reached 299.1 million tons of shipping. The Canal has continually transformed its structure and adjusted to trade requirements and international maritime transport technologies. In this way, the Canal has managed to increase its competitiveness in a sustainable manner. A description of each major Canal renovation follows:

- Constructing Madden Dam between 1930 and 1936, to increase Canal water capacity and flood control in Chagres River.
- Lighting the locks between 1964 and 1977, to increase Canal capacity by permitting night lockages.
- Renovating the locomotive fleet, starting in 1964, to improve the reliability and increase Canal operational capacity by reducing lockage times and facilitating routine and safe transit of Panamax vessels.
- Widening the Gaillard Cut from 91.5 meters (300 feet) to 152 meters (500 feet) between the early 1930's and 1971, to increase Panamax vessels transits.
- Deepening navigational channels in the 1970s, to maintain the route's competitiveness by offering its users a highly reliable depth that met their draft requirements.

To increase the capacity to handle the continuous growth in the number of transits and vessel size, the following works have been completed from the 1980s to the present:

(1) a second Gaillard Cut widening from 152 meters (500 feet) to 192 meters (630 feet) in the straight segments and up to 222 meters (730 feet) in the curve,

(2) a third Gaillard Cut Widening and Straightening to increase the channel width to a minimum of 218 meters throughout,

(3) the replacement of all lock locomotive tracks,

(4) the replacement and increase of the locomotives fleet with modern and powerful units, and

(5) the increase and modernization of the tugboat fleet. At present, the deepening of Gatun Lake and Gaillard Cut's navigational channels is about to be completed; the objective of this project is to raise the system's usable water yield, as well as to deepen the Canal's Pacific and Atlantic side entrances to enhance navigational safety.

Panamax to New Panamax Ships

Panamax and New Panamax are terms for the size limits for ships traveling through the Panama Canal. Formally, these limits and requirements are published by the Panama Canal Authority (ACP), titled "Vessel Requirements". These requirements also describe topics like exceptional dry seasonal limits, propulsion, communications, and detailed ship design. The allowable size is limited by the width and length of the available lock chambers, by the depth of water in the canal, and by the height of the Bridge of the Americas since that bridge's construction. These dimensions give clear parameters for ships destined to traverse the Panama Canal and have influenced the design of cargo ships, naval vessels, and passenger ships.

Panamax specifications have been in effect since the opening of the canal in 1914. Ships that do not fall within the Panamax-sizes are called post-Panamax. In 2009 the ACP published the "New Panamax" that will be in effect when the canal's third set of locks, larger than the current two, becomes operational. The increasing prevalence of vessels of the maximum size is a problem for the canal, as a Panamax ship is a tight fit that requires precise control of the vessel in the locks, possibly resulting in longer lock time, and requiring that these ships transit in daylight. Because the largest ships traveling in opposite directions cannot pass safely within the Culebra Cut, the canal effectively operates an alternating one-way system for these ships.

Panama Dimensions

Panamax is determined principally by the dimensions of the canal's lock chambers, each of which is 110 ft. wide, 1,050 ft. long, and 41.2 ft. deep. The usable length of each lock chamber is 1,000 ft. The available water depth in the lock chambers varies, but the shallowest depth is at the south sill of the Pedro Miguel Locks and is 41.2 ft. at a Miraflores Lake level of 54 ft 6 in. The height of the Bridge of the Americas at Balboa is the limiting factor on a vessel's overall height; the exact figure depends on the water level. The maximum dimensions allowed for a ship transiting the canal are:

Length-Over all (including protrusions): 950 ft. Exceptions:

- Container ship and passenger ship: 965 ft.
- Tug-barge combination, rigidly connected: 900 ft. over all
- Other non-self-propelled vessels-tug combination: 850 ft. over all;

Width (beam)-Width over outer surface of the shell plating: 106 ft. General exception: 107 ft., when draft is less than 37 ft. in tropical fresh water.

Draft-39.5 ft. in Tropical Fresh Water (TFW). The name and definition of TFW is created by ACP using the freshwater Lake Gatún as a reference, since this is the determination of the maximum draft. The salinity and temperature of water affect its density, and hence how deep a ship will float in the water. Tropical Fresh Water (TFW) is fresh water of Lake Gatún, with density 0.9954 gms/cc, at 29.1 °C (84 °F). The physical limit is set by the lower (seaside) entrance of the Pedro Miguel locks. When the water level in Lake Gatún is low during an exceptionally dry season the maximum permitted draft may be reduced. Such a restriction is published three weeks in advance, so ship loading plans can take appropriate measures.

Air draft-190 ft. measured from the waterline to the vessel's highest point; limit also pertains to Balboa harbor. Exception: 205 ft. when passage at low water (MLWS) at Balboa is possible. All exceptions are typically allowed only after specific request and an investigation, and on a once- or twice-only basis.

A Panamax cargo ship would typically have a DWT of 65,000–80,000 tonnes, but its maximum cargo would be about 52,500 tonnes during a transit due to draft limitations in the canal.

The longest ship ever to transit was the San Juan Prospector, now the Marcona Prospector, an ore-bulk-oil carrier that is 973 ft. long, with a beam of 106 ft. The widest ships to transit are the four Iowa-class battleship (Iowa, New Jersey, Missouri, and Wisconsin), which have a maximum beam of 109 ft., leaving less than 6 in margin of error between the ships and the walls of the locks.

The USS Missouri, one of the Iowa-class battleships, makes a very tight fit as she passes through the Miraflores Locks of the Panama Canal in October 1945.

Post-Panamax ships

Post-Panamax or over-Panamax denote ships larger than Panamax that do not fit in the canal, such as supertankers and the largest modern container and passenger ships. The first known post-Panamax ships were the Japanese Yamato-class battleships.

2006 Expansion plan and the New Panamax

On October 22, 2006, the Panama Canal Authority (with the support of the Electoral Tribunal) held a referendum for Panamanian citizens to vote on the Panama Canal expansion project. The expansion was approved by a wide margin, with support from about 78% of the electorate. It is estimated that the project will be completed by 2015 and will cost $5.3 billion; this sum is expected to be recovered within 11 years.

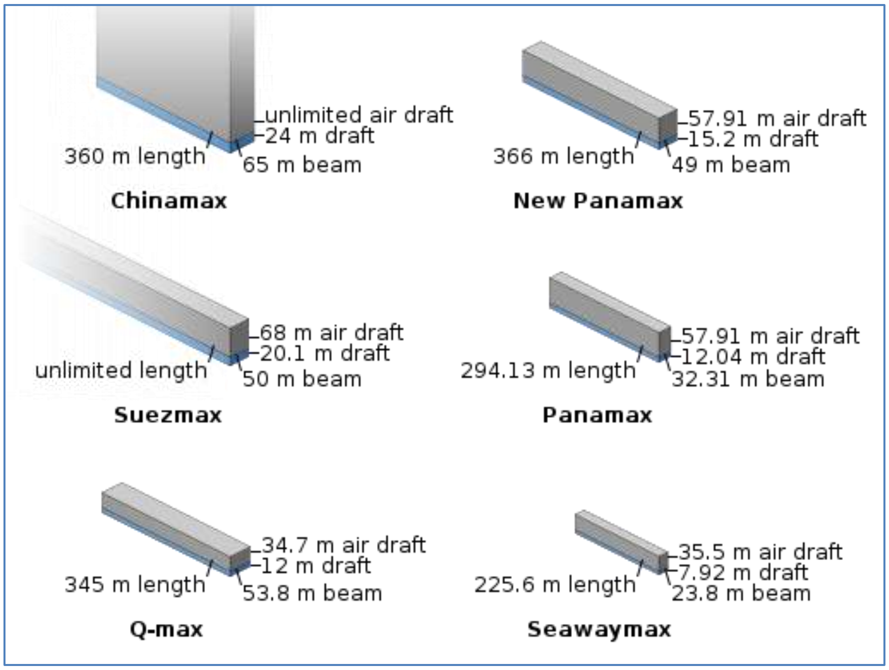
New Panamax

The plans to build another set of locks, larger than the older ones, have led to the creation of New Panamax, based on new lock dimensions of 1,400 ft. in length, 180 ft (55 m) in beam, and 60 ft. in depth. Naval architects and civil engineers are already taking into account these dimensions for container ships. After this expansion, the Panama Canal will be able to handle vessels of cargo capacity up to 13,000 twenty-foot equivalent units (TEU); currently, it can only handle vessels up to about 5,000 TEU. The New Panamax standard will be able to accommodate ships up to 120,000 DWT.

I TEU Container = 20’Lx 8’W x 8’6”H

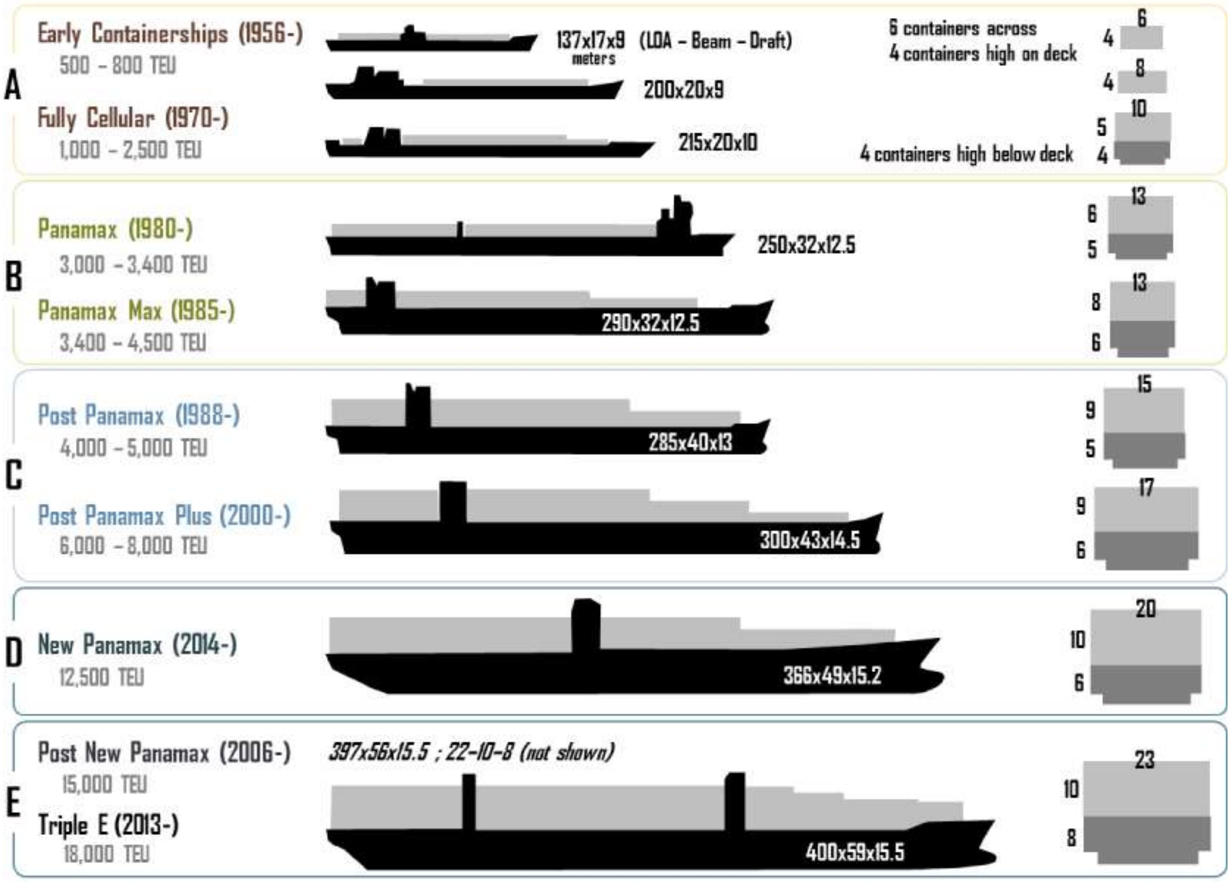
However, even after opening the new, much larger locks, there will be ships that will not be able to pass through the Panama canal. These include Maersk E-class and future Maersk Triple E class container ships, TI class supertankers, and Valemax ore carriers, all of which are too wide for the new locks. Furthermore, while the world's largest cruise ships, Oasis of the Seas and Allure of the Seas, will fit within the new locks, they will not be able to pass under the Bridge of the Americas even at low tide.

Several ports, including the ports of New York City, Norfolk, and Baltimore, all on the east coast of the United States, have already increased their depth to at least 50 ft. to accommodate these changes; the Port of Miami has recently approved the same in a project known as the "Deep Dredge" and will be the closest deep-water port to the Panama Canal in the US. The Port Authority of New York and New Jersey is planning to raise the clearance of the Bayonne Bridge to 215 ft., at a cost of $1 billion, to allow New Panamax ships to reach container port facilities in New Jersey. As of April 2012, a controversy between Savannah, Georgia, and Charleston, South Carolina, over limited federal funding for dredging/deepening projects— including both state and federal lawsuits filed by environmental groups in both states opposing the techniques planned to be used in dredging the Savannah River—also revolves around attracting the business of carriers whose fleets include New Panamax vessels. Jacksonville, Florida, is pursuing its "Mile Point" project with the prospect of deepening the St. John's River in anticipation of Post-Panamax traffic; Mobile, Alabama, has completed the deepening of its harbor to 45 ft. for the same reason; and other ports seem likely to follow suit.



Size Comparison	Original Locks	Panamax Limits	Thirds Set of Locks	New Panamax Limits
Length	1050’	965’	1400’	1200’
Width	110’	106’	180’	161’
Height	41.2’	39.5’	60’	50’
TEU		5,000		12,000

Ship comparison over time



Competition and the Impact of Panama Canal Expansion

The Panama Canal expansion is expected to affect global transportation trade routes. The Panama Canal's main competitors for shipments from Asia to the U.S. East Coast are the U.S. Intermodal System and the Suez Canal. The Panama Canal is an efficient route, but is reaching its maximum capacity. However, this problem will be resolved when the Panama Canal Expansion Project is completed.

The Suez Canal route, especially, competes with the Panama Canal in the South and Southeast Asia–U.S. East Coast route due to its shorter navigation time of 21.1 days and its capacity to handle Post-Panamax vessels. The U.S. Intermodal System has the shortest ocean navigation time (Asia to U.S. West Coast) of 12.3 days. Transit time from the West Coast to the East Coast is another 6 days, for a total transit time from Asia to the East Coast of about 18.3 days. However, the reliability of ports and railroads frequently is compromised by labor problems and capacity expansion challenges. For the U.S. Intermodal System to remain competitive in the face of the Panama Canal expansion, further investment in U.S.

infrastructure and a more integrated approach is needed to reduce bottlenecks in the system.

More than 95 percent of U.S. cargo imports arrive by ships. To accommodate this increase in global trade, shipbuilders are making larger vessels. However, the larger Post-Panamax vessels require deeper and wider shipping channels, greater overhead clearance, and larger cranes and shore infrastructure. Some U.S ports, such as the Ports of Long Beach, Savannah, Oakland, Charleston, and Seattle, can receive the Post-Panamax vessels. However, the efficiency of these ports is reduced by congestion caused by inland rail and road chokepoints. Congestion affects the service reliability of the U.S. transportation system. Capacity expansion in the transportation system is critical for economic growth.

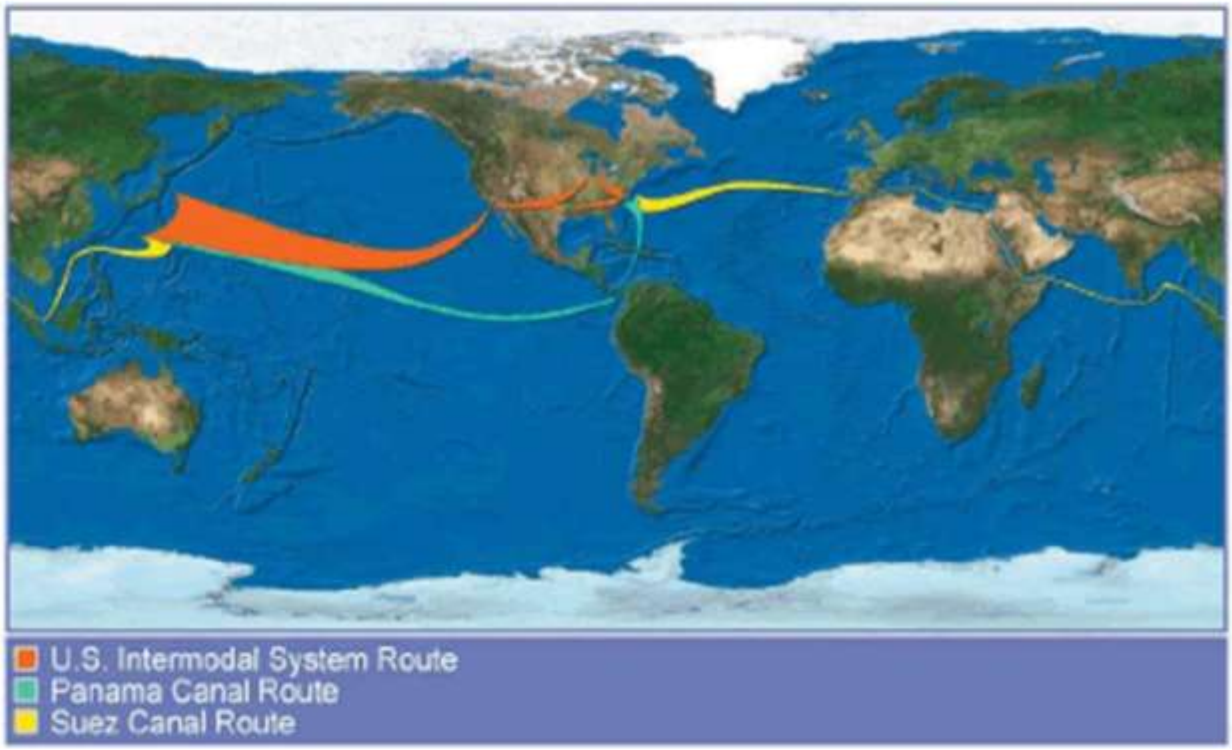
Panama Canal Market Segments and Competitiveness

The Panama Canal Authority classifies its market into eight segments:

1. Containerships
2. Dry bulk vessels that carry grains, ores, or their derivatives
3. Vehicle carriers
4. Liquid bulk vessels, which transport chemical products, gases, and oil derivatives
5. Reefers or refrigerated transport
6. Cruise ships
7. General cargo vessels
8. Miscellaneous vessels such as fishing boats, navy and research vessels, dredges, and barges

Containerships are the Canal's main source of income, followed by dry bulk, vehicle, and liquid bulk.

The Panama Canal faces direct competition from alternative routes such as the U.S. Intermodal System, the Suez Canal, the Cape of Good Hope, and Cape Horn. Currently, the main competitors are the U.S. Intermodal System and the Suez Canal (Figure 1). In 2006, the maritime transpacific route—containership services between Asia and the U.S. West Coast was the preferred route, accounting for 75 percent of Asian imports with an average navigation time of 12.3 days, plus 6 days from the West to the East Coast, totaling about 18.3 days. Second is the Asia−Panama Canal−U.S. East Coast route with 19 percent of Asian imports and an average navigation time of 21.6 days, followed by the Asia−Suez Canal−U.S. East Coast route handling 6 percent of Asian imports with an average navigation time of 21.1 days.



5

The Suez Canal

In the 13th century BC, the pharaohs created a canal linking the Nile River delta and the Red Sea. The Suez Canal remained navigable, but was neglected for several thousand years. It was re-excavated or modified many times, then finally abandoned in the 8th century AD. On April 25, 1859, the Companies Universally du Canal Maritime de Suez (Universal Company of the Maritime Suez Canal) began re-dredging the canal. It was opened to navigation again on November 17, 1869, with a license to operate for 99 years at a total cost of $100 million. In 1956, the Suez Canal was nationalized by the Egyptian Government.

The Suez Canal links the Mediterranean Sea to the Gulf of Suez on the Red Sea. On June 5, 1967, during the Six-Day War, it was closed and blockaded against Israel by Egypt. It was reopened on June 10, 1975. The Canal is 118 miles long (190 km); it contains no locks, and is 77 feet (23.5 m) deep. Ships with up to 68 feet (20.7 m) draft can navigate the Canal. Egypt plans to increase the draft to 72 feet (22 meters) by 2010, allowing for passage of Supertankers.[4] Currently, it is owned and maintained by the Suez Canal Authority of the Arab Republic of Egypt.

- Competitiveness

The Suez Canal route competes with the Panama Canal in the Asia–U.S. East Coast route, especially in cargo originating in South[1] and Southeast[2] Asia, due to its shorter navigation time to the U.S. East Coast and its capacity to handle Post-Panamax vessels. Currently, the Panama Canal route and the transpacific route connecting to the U.S. Intermodal System are more efficient for shipments originating in Northeast Asia. For example, a weekly containership service with the same cargo capacity between Northeast Asia and the U.S. East Coast using the Suez Canal requires about 11 vessels; each vessel makes 4.7 round trips per year, with a round-trip travel time of 77 days. Traveling through the Panama Canal, each vessel makes 6.5 round trips per year, with a 56-day round-trip travel time. An alternative to the Suez Canal is the longer trip around Africa by the Cape of Good Hope.

Bigger ships and ships avoiding the Canal toll fees often take this route. In addition, this route minimizes the potential of piracy off the Coast of Somalia. Private shipping companies paid about $150 million to pirates in 2008.

- Panama versus the Suez Canal

The Suez Canal route's main advantage is its ability to handle Post-Panamax vessels, which offers the possibility of increased revenue from greater productivity. For instance, a weekly service of 11 Post-Panamax vessels (8,000 TEUs3 capacity) has an annual productivity of 38,000 TEUs per vessel and a total annual service of 410,000 TEUs through the Suez Canal. However, the same service using Panamax vessels (4,800 TUEs) through the Panama Canal results in an annual productivity of almost 31,000 TEUs per vessel and a total service capacity of 248,000 TEUs. This represents an 18-percent decrease in each vessel's annual productivity and a nearly 40-percent drop in total service capacity.

The Suez Canal's average transit time is longer than that of the Panama Canal —14 hours for a southbound convoy and 10 hours for a northbound. The Panama Canal's average transit time was only 9 hours in 1999, but it increased nearly 45 percent in 2008, reaching 13.04 hours. Delays and interruptions in Canal traffic reduce the Canal's service reliability, causing the Panama Canal route to become more expensive and impairing the Canal's competitiveness. With the expansion of the Panama Canal, service reliability should increase because there will be fewer delays in transit time.

U.S. Intermodal System

The U.S. Intermodal System is a complex of three distinct transportation modes: ocean shipment, movement by rail, and truck transport. Cargo must be transferred from one mode to the other, unlike the Canal routes, which consist of only the ocean container mode, and require no transfers. The U.S. Intermodal System is the main competitor with the Panama Canal expansion in the Northeast Asia –U.S. East Coast route. The Canal route is less costly and highly reliable but has a longer navigation time (21.6 days) than the U.S. Intermodal System route (18.3 days, depending on the carrier). The U.S. Intermodal System route comprises the transpacific maritime route (containership services between Asia and the U.S. West Coast), the U.S. East Coast Ports, the U.S. rail network, and the interstate highway system.

The U.S. Intermodal System comprises such diverse operators as ports, railroads, trucks, transshipment areas, and municipal and state governments. The system’s efficiencies are dependent on an advanced and sophisticated network of large commercial operators with highly trained personnel, as well as support services and industries to maintain the network.

- Competitiveness

The major advantage of the U.S. Intermodal System is the opportunity it offers to develop economies of scale in the transpacific maritime route, which frequently uses Post-Panamax containerships, as it requires only five ships for a weekly service rotation compared with the eight ships required by the Panama Canal route. However, port and railroad reliabilities have been affected by labor problems (strikes and shortage of labor to handle new cargo) and congestion caused by capacity expansion challenges. Ports must compete with community and environmental land uses for land on which to expand. As trade increases, many of the U.S. top 10 container ports, 5 are reaching their capacity. The ports of Los Angeles/Long Beach (LA/LB), New York/New Jersey (NY/NJ) , Seattle/Tacoma, Savannah, and Oakland accounted for nearly 69 percent of the U.S. foreign container trade in 2008.

➢ Capacity Challenges

U.S. port container traffic is expected to double or triple by 2030. In the coming years, the market for transportation services will be determined by rising transportation costs triggered by increasing port capacity and environmental initiatives. Port costs are expected to be pushed up by:

- The switch to low-sulfur and cleaner-burning distillate fuels to reduce air pollution from ships, terminal facilities, and truck and rail connectors in and near highly populated port regions.
- Improving port terminal facilities' efficiency, hours of operations, and upgrading connections to regional and national road and rail networks.
- Reducing congestion in the current primary ports of LA/LB, and NY/NJ.

On average, the ports of LA/LB account for 43 percent of total TEU imported in the United States. New national policies and improved public-private investment coordination would be needed to increase capacity in the primary ports as well as to offer alternative routes.

<u>Alternative Intermodal System Routes</u>

Cargo may be diverted from southern California to other countries, such as the Port of Prince Rupert, Canada, and the Port of Lázaro Cárdenas and the port planned at Punta Mexico trade. The port's access channel is 18 meters and is located 532 miles closer to Houston by rail than Long Beach. In 2008, container traffic almost doubled—from 270,240 TEUs to 524,791 TEUs—from a year earlier and is expected to receive 6 million containers from Asia before 2015. Cargo is transported to the U.S. East Coast through the intermodal Lázaro Cárdenas-Kansas City corridor, which is operated by Kansas City de Mexico. To ship a container from

China takes approximately 13 days to the Port of Lázaro Cardenas and 90 hours from the Port to Houston, Texas.

The Multimodal Punta Colonet project, located in the Baja California Peninsula about 150 miles south of San Diego, has the primary purpose of facilitating Asian exports to the United States. It can handle 6 million TEUs at an estimated cost of $5 billion. This is the most important project of the 2007-2012 Mexico National Infrastructure Plan, yet it has been delayed twice due to the world financial crisis and market outlook. Both the Punta Colonet project and the Port of Manzanillo expansion face environmental challenges.

In 2005, the Canadian Government created the Asia-Pacific Gateway and Corridor Initiative to strengthen Canada's competitive position in international commerce as a completely integrated intermodal system. It will include British Columbia Lower Mainland and Prince Rupert ports, road and rail connections stretching across western Canada and south to the United States, key border crossings, and major Canadian airports. The main focus is on trade with the Asia-Pacific region. The ports of western Canada are 1 to 2 days closer sailing time to Asia-Pacific ports than the U.S. western ports. For example, sea journeys between Shanghai and North America are 68 hours faster through Prince Rupert than through Los Angeles and 32 hours faster through Vancouver than through Los Angeles.

Competitive transportation systems are critical for economic growth. Increases in global trade have put a strain on the U.S. logistics system and the world transportation network. Understanding current trade flows and continuing changes in international trade lanes is critical to optimizing system investment and operations within our own borders. Most U.S. trade moves through the Panama Canal, the Suez Canal, the Cape of Good Hope, and the U.S. Intermodal System. The Panama Canal expansion will increase efficiency to the U.S. Intermodal System by decongesting the West Coast main ports of LA/LB. Trade could be diverted to the East Coast ports for faster delivery. Transportation cost might decline in destination countries that have deeper access channels and the capacity to handle Post-Panamax vessels. For the U.S. Intermodal System to remain competitive in the face of the Panama Canal expansion, further investment in U.S. infrastructure and a more integrated approach is needed to reduce bottlenecks in the system. Future research should examine how expansion of the Panama Canal may redistribute trade volumes across the U.S. Intermodal System, including ports, railroads, and trucks. Trade reallocation to the East Coast would increase truck traffic and overall vehicle congestion to major interstates such as I-95 Corridor.

MODULE D - EXPANSION PROJECT DESIGN AND CONSTRUCTION

Expansion Project Scope and Design Basis

The Panama Canal expansion program, Third Set of Locks, was initiated by the Panama Canal Authority soon after they took control of the Canal. The Panama Canal Authority (ACP) is the entity of the Government of Panama established under Title XIV of the National Constitution with exclusive charge of the operation, administration, management, preservation, maintenance, and modernization of the Canal, as well as its activities and related services, pursuant to legal and constitutional regulations in force, so that the Canal may operate in a safe, continuous, efficient, and profitable manner. The primary difference between U.S. and ACP operation of the Canal is the profit part.

The new Third Set of Locks consists of two lock complexes located at each end of the Panama Canal on the Atlantic and Pacific Sides, respectively. The existing Canal consists of two "lanes" of lock chambers to allow two ships to simultaneously cross the isthmus in either direction; hence "Two Sets of Locks." The new construction will add a new lane; a "Third Set of Locks" for Post Panamax size ships. The function of the new set of locks is to raise transiting vessels, larger than those that can be accommodated by the existing set of locks, from the Atlantic or Pacific Ocean water level, to the Gatan Lake water level (approximately 26.5 meters (87 feet) above sea level), and subsequently, lower the transiting vessels from the Gatan Lake water level to the other ocean water level. The new lock operations for raising and lowering vessels will be performed in three steps up to the lake and three

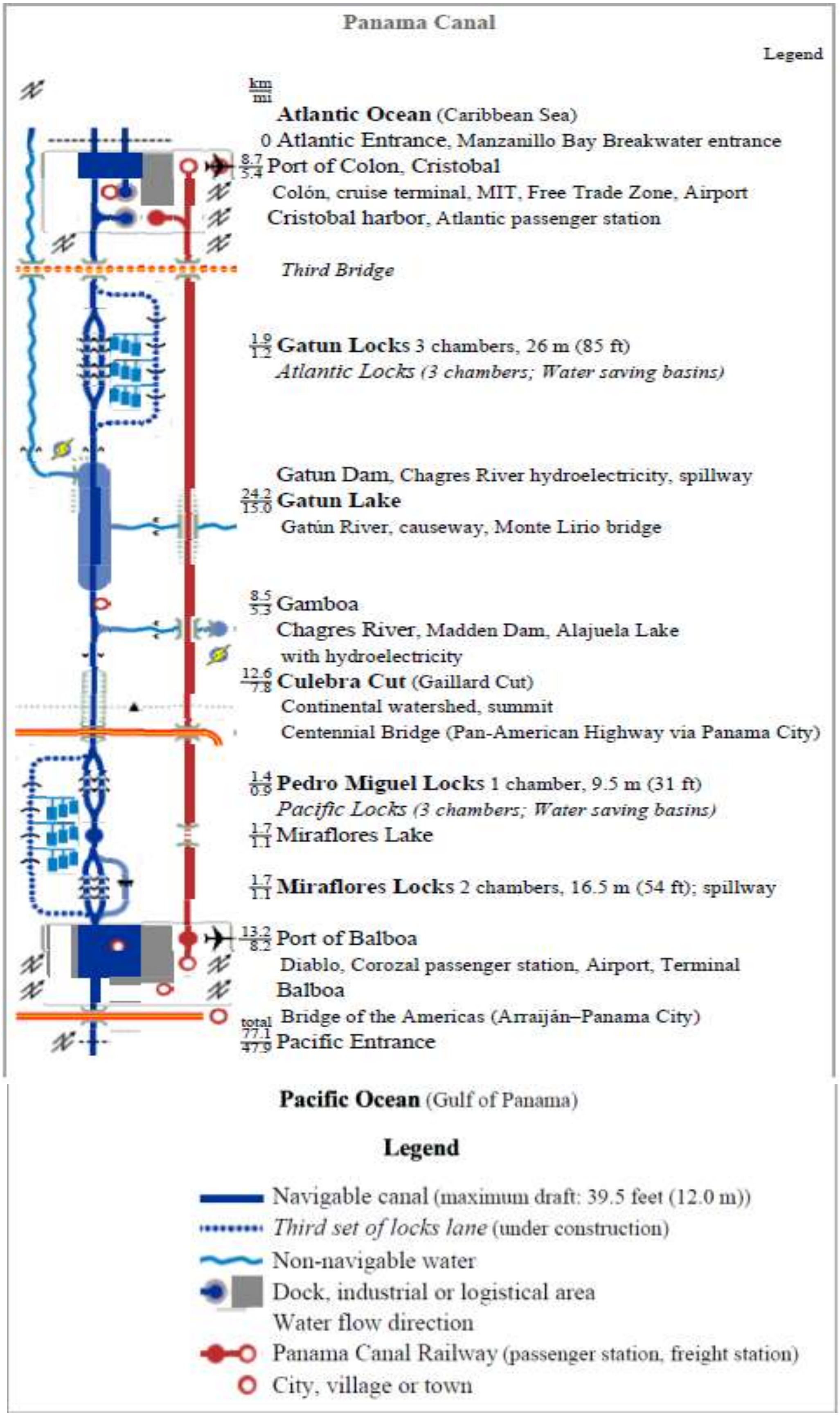
Figure 1-1 CICP Rendering of the 3rd Set of Pacific Locks, the Atlantic locks will be similar.

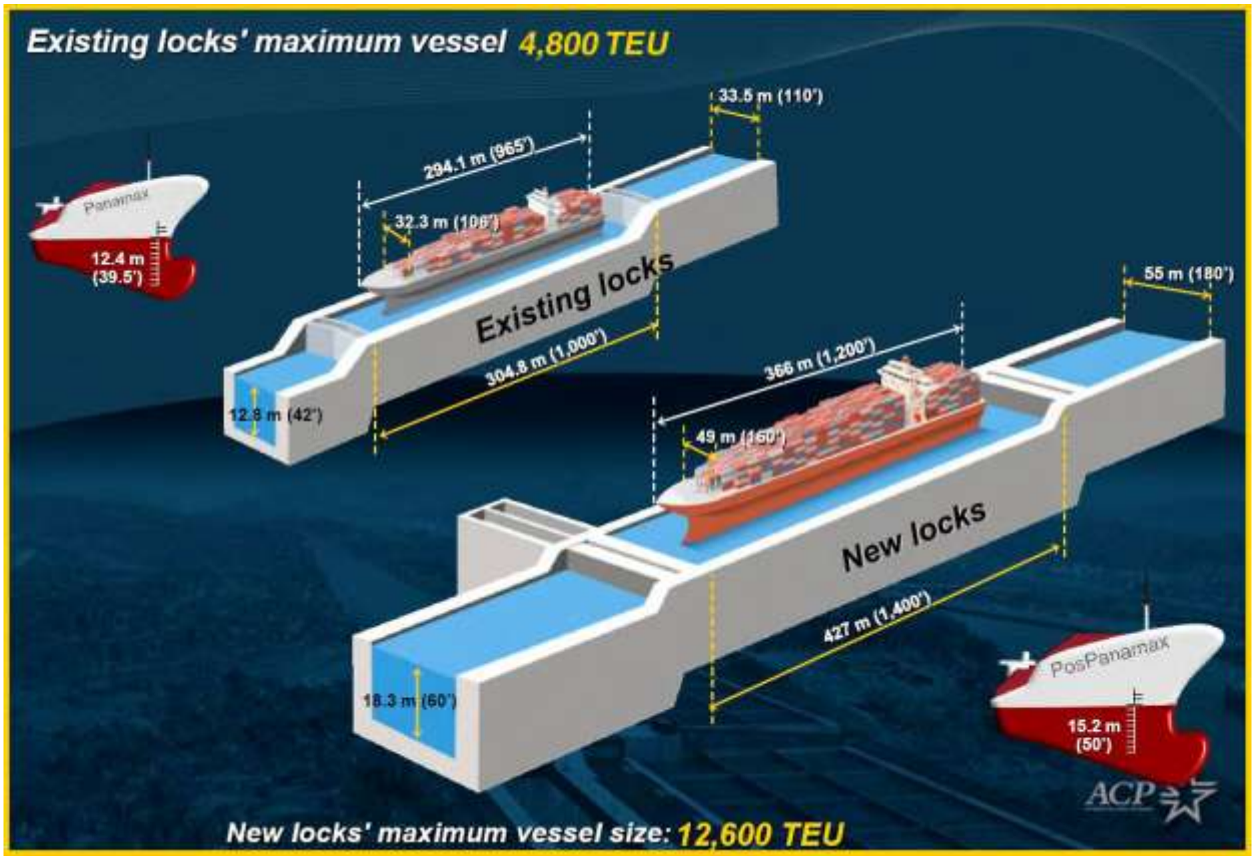
steps down by means of the Lower, Middle, and Upper Chambers located at each Lock Complex. In addition to the size of the lock chambers, the availability of water can also be a limitation on the capacity of the Panama Canal, especially during periods of reduced rainfall in the Canal watershed area. Water Saving Basins are used in the design of the new locks to allow ships with two and a half times the cargo carrying capacity to transit the Canal using approximately the same amount of water as the existing sets of locks.

Each new lock complex includes Approach Channels, Approach Structures, Wing Walls, Lock Heads, Lock Chambers, Water Saving Basins, Lock Gates, Valves, Electrical Systems, Control Systems, Infrastructure (buildings, roads and utilities) and Mechanical Systems required for the operation and maintenance of the locks. The lock complexes provide fully operational transit systems for Post-Panamax vessels at each location. See the rendering of what the new locks will look like on the previous page.

Other important project features are the Borinquen Dams located at the Gatan entrance of the Pacific Site Locks.

The execution of the project to design and build the Third of Locks for the Panama Canal consists of the detail design of the new lock structures and control systems, the construction of the industrial plant to crush local Basalt rock for the required aggregates and sand to produce the required 3,000 to 5,000 cubic meters of concrete per day for the Lock Chambers, Lock Heads, Water Saving Basins and Buildings. Extensive excavation of soil and rock will be required to provide the locations for the new structures. To support this activity, shops and warehouses are required to fabricate the steel reinforcement and formwork for the concrete placed. Also to support the construction maintenance shops have been constructed for the heavy equipment and testing laboratories are being operated to continuously verify the characteristics of the materials being used. To support the workforce, housing, eating facilities and first aid stations have been constructed or acquired. Below is a flow diagram of the new locks integrated with the current two lock system.


Panama Canal
Legend
km/mi
Atlantic Ocean (Caribbean Sea)
0 Atlantic Entrance, Manzanillo Bay Breakwater entrance
8.7/5.4 Port of Colon, Cristobal
Colón, cruise terminal, MIT, Free Trade Zone, Airport
Cristobal harbor, Atlantic passenger station
Third Bridge
1.9/1.2 Gatun Locks 3 chambers, 26 m (85 ft)
Atlantic Locks (3 chambers; Water saving basins)
Gatun Dam, Chagres River hydroelectricity, spillway
24.2/15.0 Gatun Lake
Gatún River, causeway, Monte Lirio bridge
8.5/5.3 Gamboa
Chagres River, Madden Dam, Alajuela Lake
with hydroelectricity
12.6/7.8 Culebra Cut (Gaillard Cut)
Continental watershed, summit
Centennial Bridge (Pan-American Highway via Panama City)
1.4/0.9 Pedro Miguel Locks 1 chamber, 9.5 m (31 ft)
Pacific Locks (3 chambers; Water saving basins)
1.7/1.1 Miraflores Lake
1.7/1.1 Miraflores Locks 2 chambers, 16.5 m (54 ft); spillway
13.2/8.2 Port of Balboa
Diablo, Corozal passenger station, Airport, Terminal
Balboa
Bridge of the Americas (Arraiján–Panama City)
total 77.1/47.9 Pacific Entrance
Pacific Ocean (Gulf of Panama)
Legend
Navigable canal (maximum draft: 39.5 feet (12.0 m))
Third set of locks lane (under construction)
Non-navigable water
Dock, industrial or logistical area
Water flow direction
Panama Canal Railway (passenger station, freight station)
City, village or town



TEU=Standard unit for describing a ship's cargo carrying capacity, or a shipping terminal's cargo handling capacity. A standard forty-foot (40x8x8 feet) container equals two TEUs (each 20x8x8 feet).

Engineering works

The whole program to increase the capacity of the Panama Canal involves three main components besides the construction of new lock facilities at the Atlantic and Pacific ends of the Canal. There is the excavation of an access channel to the new locks on the Pacific end, the widening and deepening of existing navigational channels at the sea entrances and the elevation of Gatun Lake's maximum operating level. Gatun Lake is a 456 km man-made lake, whose surface is roughly 26.5 m above mean sea level. Together with upstream Alajuela Lake, they provide all of the freshwater required to operate the canal, as well as potable water for residential and industrial use in Panama City.

The civil engineering involved is monumental in scale, requiring the excavation and dredging of some 147 million cubic metres of earth and rock. This is made possible by using – among many large pieces of equipment – the world's largest floating drilling and blasting vessel which has 10 drilling towers. In total, an extra 8 km of channels will be excavated to connect the new locks to existing shipping lanes.

Around 10,000 workers will be employed on the project. Panama's Gatun Lake, which forms a large part of the shipping route, will be deepened by 1.2 m and widened by an extra 128 m (for a total of 356 m in the turns). The maximum operating lake level will also be raised by 0.45 m to provide, on average, an extra 165 million gallons of water per day which will allow about 1,100 full additional transits a year.

Lock alternatives

The new reinforced-concrete locks will each measure over a mile-and-a-half in length. The chambers will each be 427 m long, 18 m deep, and 55 m wide.

A major change compared to the existing locks will be the type of lock gates used. Miter-style lock gates – like those currently on the Panama Canal – consist of two leaf gates. They are analogous to a set of double doors, except that they close on to each other at a pitch angle of 2:3. From a plan view they form a wedge shape in the lock. Always facing the incoming water, as pressure builds up they are forced more tightly into each other and to their wall bearings. Miter gates become less efficient at longer lengths – there is no lock in the world wider than 42 m that uses this type of gates.

When fully open, they fold into the sides of the lock and this, in part, is one of their disadvantages. The lock must include gate recesses in the walls or be wider than necessary for the vessel so as to accommodate the gates (when open) and long enough so that the gates can swing open or close without damaging the vessel.

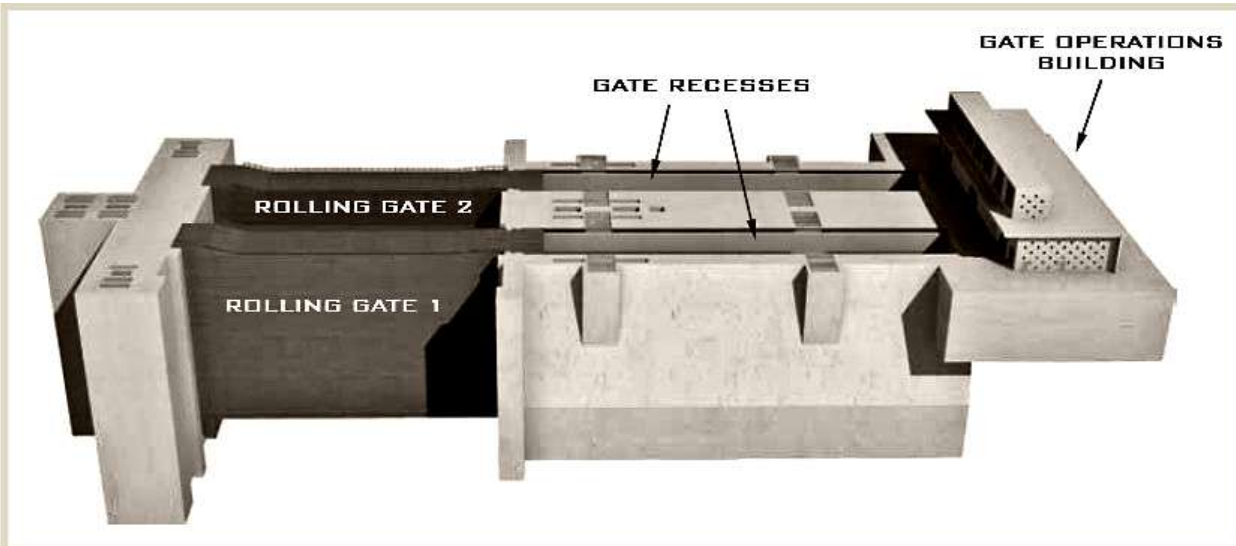
The alternative is to use rolling gates, which have been selected for the new locks. They are equivalent to sliding doors, only on a far larger scale. While the principle is simple, the engineering is formidable. Although these new gates will be built along traditional lines, with special treatment of the surface to control corrosion, they will also incorporate a number of innovations inspired by more recent locks in Europe that can accommodate bigger ships.

Rolling gates have several advantages over the much older miter gates used elsewhere on the canal. For one, rolling gates are fully retracted into recesses in the lock walls and don't take up any additional space when open. They also reduce the length of the lock only by their own width, unlike the miter gates, which project forward into the lock and take up even more precious space.

New gates

The new locks will incorporate twin gates at either end of each chamber, held in recesses at right angles to the lock wall. Both gate recesses are located in specially designed wall monoliths called 'lockheads'. Both gates weigh roughly 3,000 tonnes and rest on wagons at either end which allows them to roll in and out of the lockhead.

The twin rolling gate design introduces a valuable redundancy to the system. While one of the pair acts as the operating gate that retains water in the lock, the other acts as an auxiliary gate that serves as backup when the primary gate requires maintenance or is out of commission for any reason.



Each gate has two sets of wheels (or 'wagons') that normally carry approximately between 10% to 15% of the weight of the gate, the remainder of the weight is carried by flotation from strategically located buoyancy chambers. The upper wagon is fixed at the top corner of the gate and rolls along supports on both sides of the length of the recess. The other is affixed diagonally opposite at the bottom corner of the gate and rolls along the bed of the lock on crane rails. The gates are operated with a winch and motor system. When the lock is to be used, the gates are pulled forward, by means of large diameter wire ropes, sliding them into the lock. To open them, they are pulled backwards into the recesses. The time estimated for the gates to open or close is around four minutes.

Gate maintenance

The positioning of the sets of wagons on each gate allows for simplified preventive maintenance. While the top wagon is easily accessible, the bottom wagon can be taken out for maintenance by emptying the gate's internal ballast tanks which increases the buoyancy, taking the weight off the lower wagon and allowing it to be withdrawn to the surface through a strut that links the bottom of the gate to the top. The strut runs through a hollow shaft within the body of the gate, with enough restraints to allow it to carry all the operational loads and still permit removal of the wagon. The time required for replacement of a wagon has been limited to just four hours.

The fact that the rolling gates require recesses in the lockheads to house them in their open position provides for an added benefit in terms of maintenance. By placing removable bulkheads in the opening that separates the gate recess and the lock chamber, it is possible to completely empty the recess and perform gate maintenance in place, under dry dock conditions. In contrast, the existing canal gates need to be removed and taken to a remotely located synchrolift whenever they require repair or maintenance, closing down an entire traffic lane and causing severe delays.

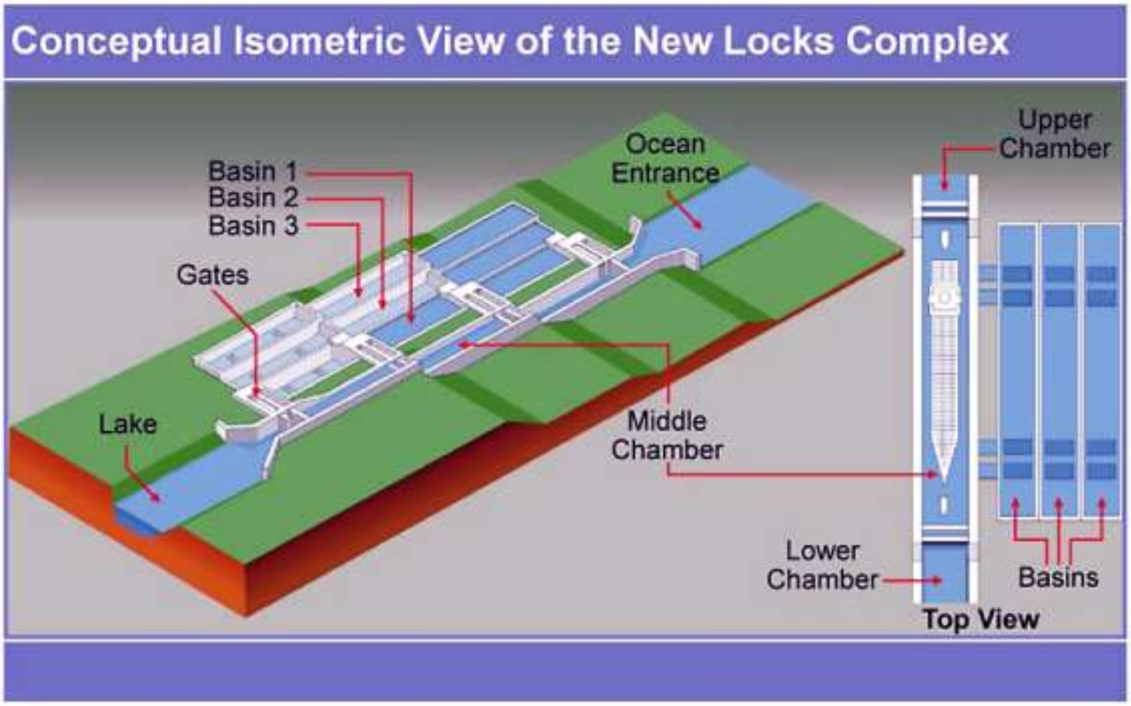
The gates are operated by electric motors. Two on each gate offer redundancy, with a third smaller emergency motor able to operate the gates – albeit much more slowly – should they both fail.

Water-saving basins

Even though the Panama Canal watershed receives 2.5 metres of annual rainfall, storage of water is a continual challenge. Gatun Lake and Alajuela Lake are reservoirs that, along with the canal watershed, supply drinking water to 95% of the population around the waterway, as well as to the locks.

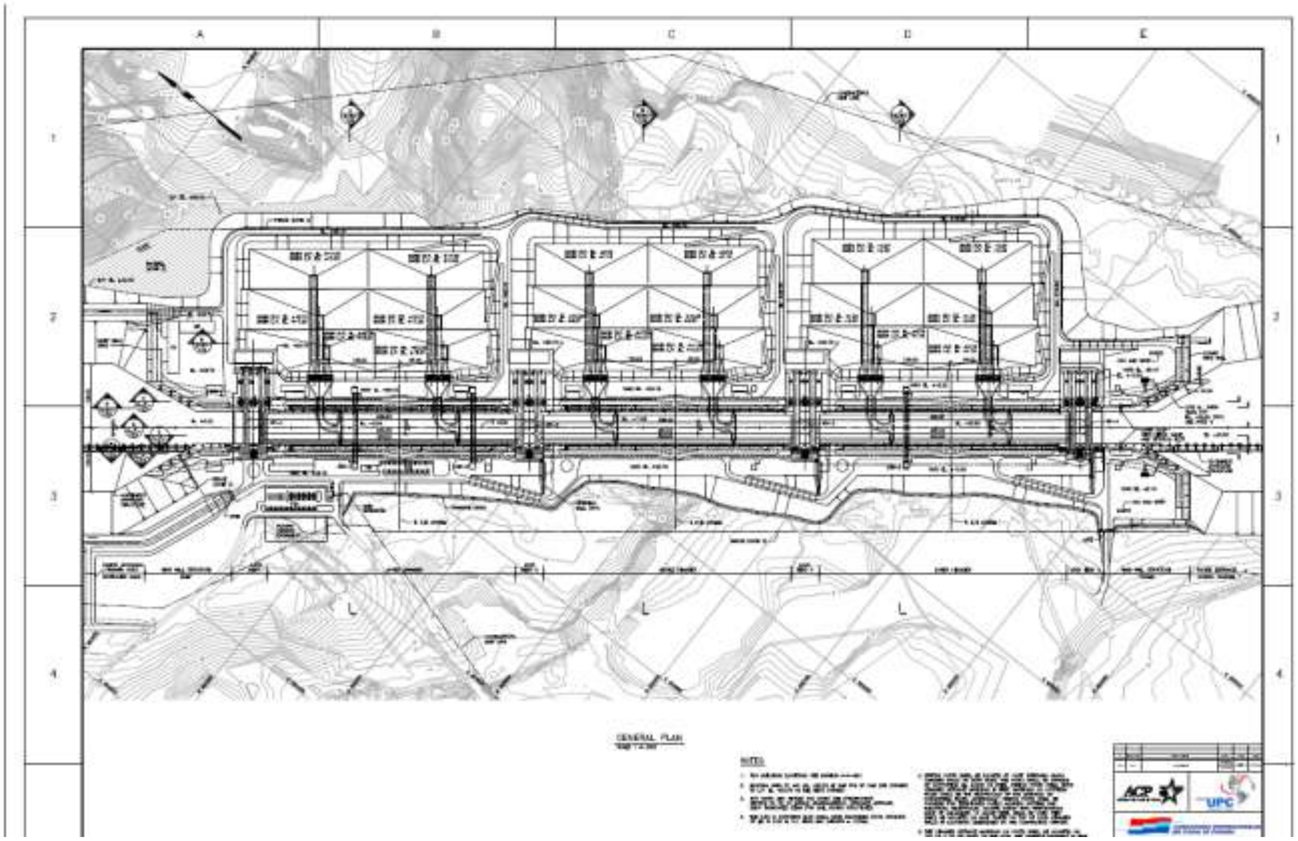
The canal operation is by itself the most considerable drain on water sources. There is also an increased demand of potable water for industrial and domestic usage due to the increasing Panamanian population and expanding industry. To help alleviate the problem, the Autoridad del Canal de Panamá found inspiration from canals in Germany, which use basins that recycle some of the water used for locking vessels.

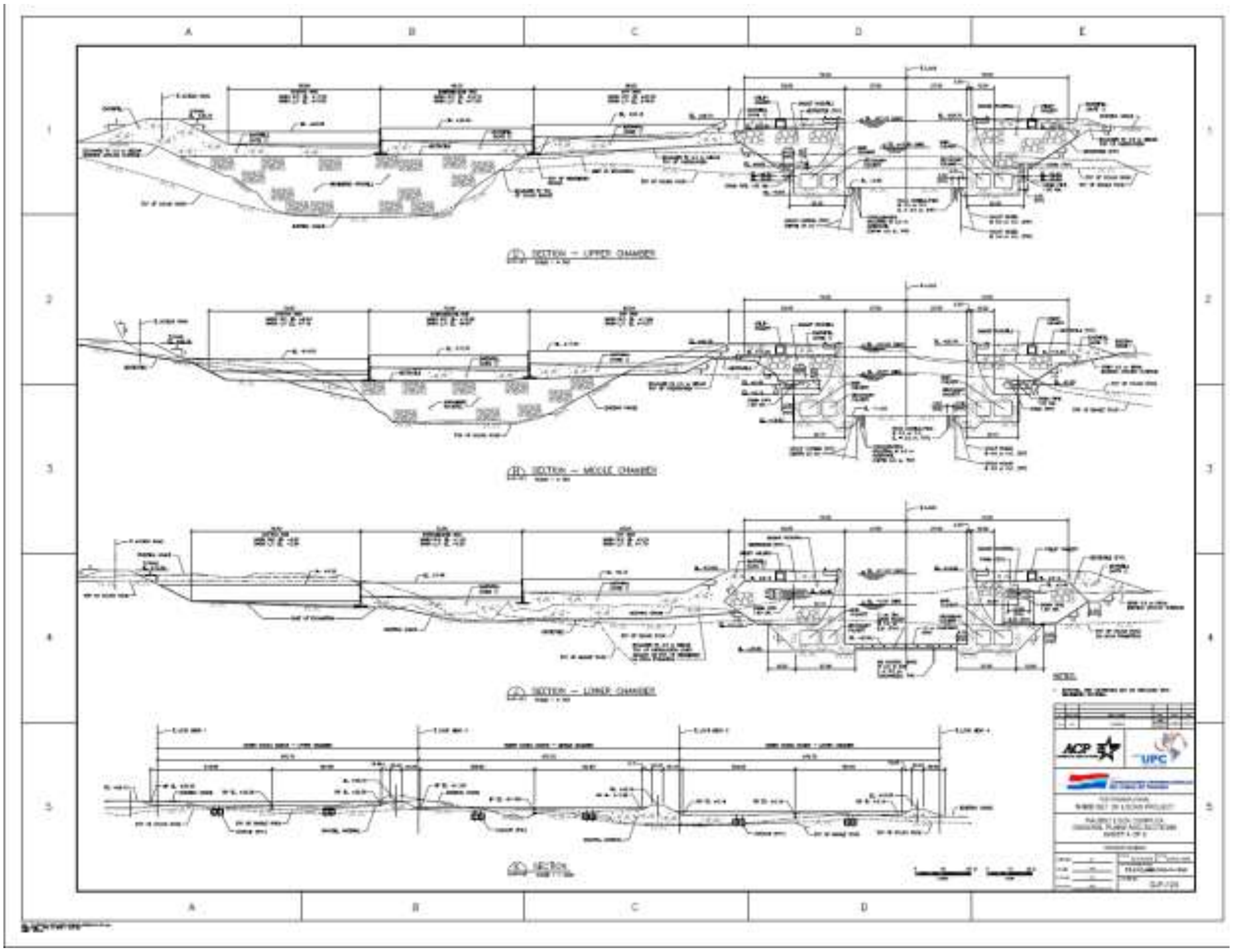
Each lock chamber in the Panama Canal's new set of locks will be connected to a group of three water-saving basins. The basins will save up to 60% of the water used in each transit and the remaining 40% will be topped up by fresh water from Gatun Lake. Without a new design incorporating water-saving basins, the expansion plans would have doubled water consumption. Instead, the new locks will use 7% less fresh water per transit than the existing locks, despite being 65% larger.



The basins work on the simple physical principle of water displacement by gravity alone. When bringing a vessel down from the lake, three-fifths of the water in the chamber is directed into the three water-saving basins. The remaining water is equalized with the water in the subsequent lock chamber. To raise the water level in the lock chamber, the process is reversed: water is released from each of the three water saving basins, one at a time, while the remaining water comes from Gatun Lake, 26.5 m above sea level, or from the lock chamber immediately upstream. A valve system holds the water in place in the lock chambers to carry out this operation. Tests are currently underway to optimize the filling and emptying system.

A numerical model developed by Deltares, the Dutch water technology institute, shows that water quality in Gatun Lake is not under threat from the new locks, even with waters of different salinities entering the system and mixing from the ships' propulsion systems.





Program Management Plan (Issued March 2010 by ACP)

The Canal is Panama’s main economic asset. Its expansion guarantees the continuous growth and development not only of the Canal, but of the economic cluster supported by it. The main goal of the Panama Canal Expansion Program (PCEP) is to increase the Canal’s capacity to capture growing demand. This will ensure the long-term sustainability and growth of the Canal’s contributions to the Republic of Panama while making the Canal more productive, safe, and efficient. To achieve its main goal, the PCEP must develop a highly effective integrated Program Team.

This Program Management Plan (PMP) lays the foundation for establishing that team. As the Program Management Team (PMT) makes decisions and establishes standards and processes, this PMP will be updated.

By having and using standards and processes, the team can focus its collective energy on the new facilities needed to meet the future throughput safely and efficiently.

A well-integrated team will also ensure that the locks function as a flawless transit system, fulfilling the Autoridad del Canal de Panamá (Panama Canal Authority [ACP]) promise to the Panamanian People. Another outcome of this type of PMP is that the individual team members will develop new skills that will benefit Panama and the ACP years beyond the completion of the PCEP.

The ACP is the entity of the Government of Panama established under Title XIV of the National Constitution exclusively responsible for operating, administering, managing, preserving, maintaining, and modernizing the Canal. The ACP is also responsible for Canal related activities and services, and ensuring that the Canal operates in a safe, continuous, efficient, and profitable manner. Because of its importance and uniqueness, the ACP is financially autonomous, has its own patrimony, and the right to administer it. The ACP has the fundamental objective of preserving the Canal so that it is always able to provide peaceful and uninterrupted service for the maritime community, international trade, and the Republic of Panama.

Program Description

The PCEP is a large-scale, multi-disciplinary construction program with a combined value of approximately $5.25 billion composed of the following major projects:

- the Atlantic Locks, Pacific Locks, water-saving basins and operating systems,
- Channel widening and deepening on both Atlantic and Pacific entrances
- Pacific Access Channel Dry Excavation,
- Freshwater Dredging (widening and deepening), and
- Raise the operating level of Gatun Lake.
- A new 6.1 km navigational channel connecting the future Post-Panamax Lock on the Pacific side to the Culebra Cut.

The PCEP will design, construct, commission, and hand over third-lane locks enabling Post-Panamax ships to pass through the Panama Canal. Over the past decades, container ships have grown, but the two locks of the 100-year-old Panama Canal have remained 1,000 feet long by 110 feet wide. The basic Post-Panamax transportation system requirements include the following:

- Width: The width between the opposite walls of each chamber shall be a minimum of 55 m. The useable width will be at least 54.4 m. The clearance between the structural walls and the hull of the vessel is for fendering (0.3 m on each side of the chamber).

• Length: The gate configuration used affects chamber length, but the following minimum usable chamber lengths will apply in each case.

− 427 m chamber length is determined by the internal chamber length dimensions between the inner gates at both ends of the chamber.

− 458 m chamber length is determined by the internal chamber length dimensions between the inner gate at one end and the outer gate at the other end.

− 488 m chamber length is determined by the internal chamber length dimensions between the outer gates at both ends.

• Water Savings Basins to Conserve: Each lock complex will provide water savings of at least 59% when Water-Saving Basins (WSBs) are used for lockages, as compared with lockages without WSBs.

• Maximum Time to Fill and Empty Locks: The maximum lockage time is the total time for a complete lockage including movements of the design vessel through each lock complex. Lockage time shall not exceed 154 minutes when using WSBs and 133 minutes when not using them. The cycle time for relay lockages shall not exceed 88 minutes with WSBs or 74 minutes when not using them.

In addition, the program's scope includes the design and execution of four excavation phases (PACs 1-4). The design of PAC-4 includes the design of the four dams that are required for the new Pacific Access Channel. PAC-4 also includes the construction of the main Borinquen dam (Dam 1E). The final design and construction of the other 3 minor dams is included in the Locks Design-Build subprogram."

The program also includes improvements to the navigation channel consisting of the dredging of existing channels to allow post-Panamax vessels to navigate safely through the Panama Canal following its expansion. This scope includes the deepening and widening of the Atlantic and Pacific entrance channels. The work with the Atlantic entrance channel will involve the dredging of about 17.1 million cubic meters of material and the excavation of 800,000. About 8.7 million cubic meters will be dredged from the Pacific entrance channel.

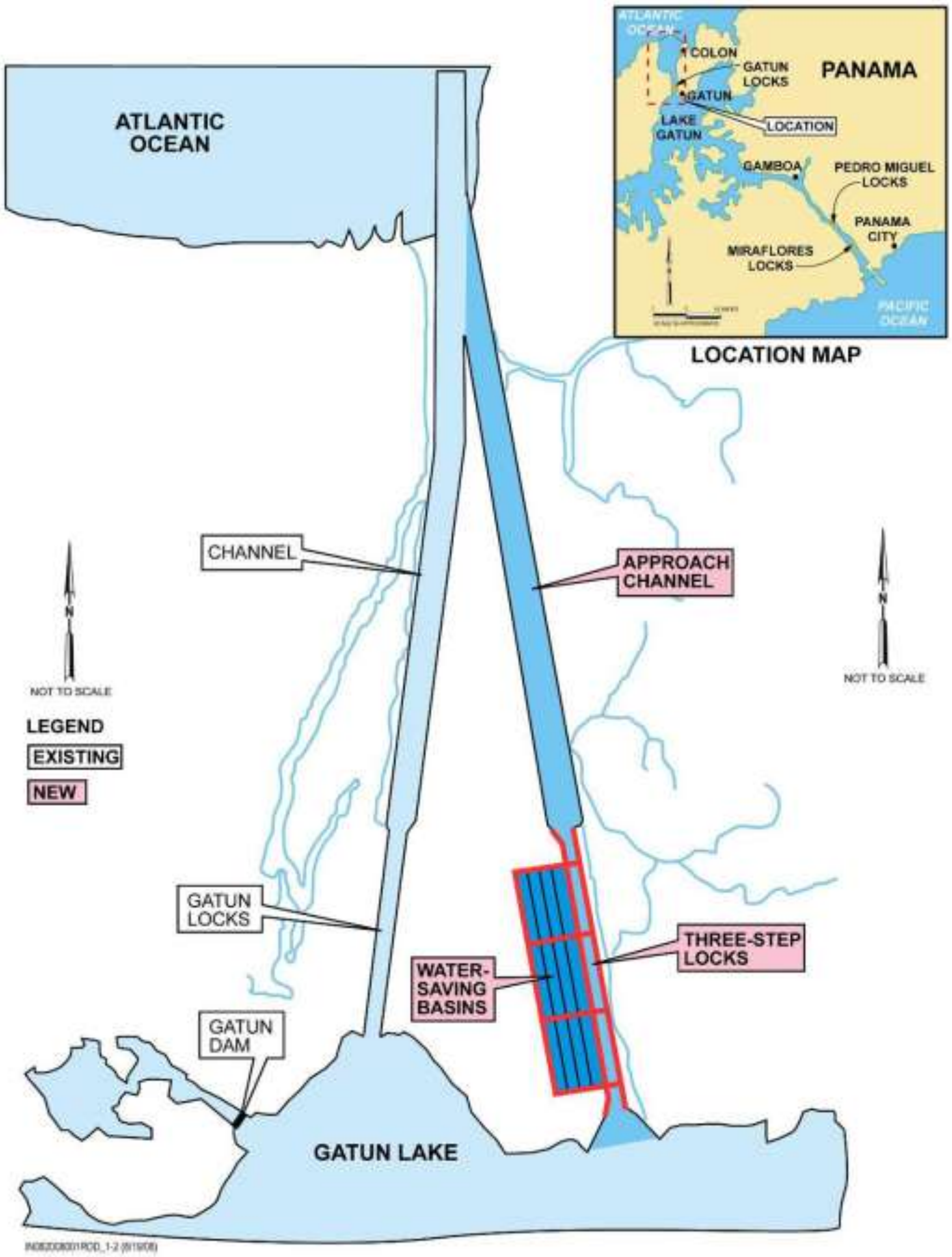
The remaining elements of the subprogram are the deepening and widening of the navigational channels in Gatun Lake and the deepening of the channels in Gaillard Cut, which will require the dredging and excavation of approximately 30 million cubic meters.

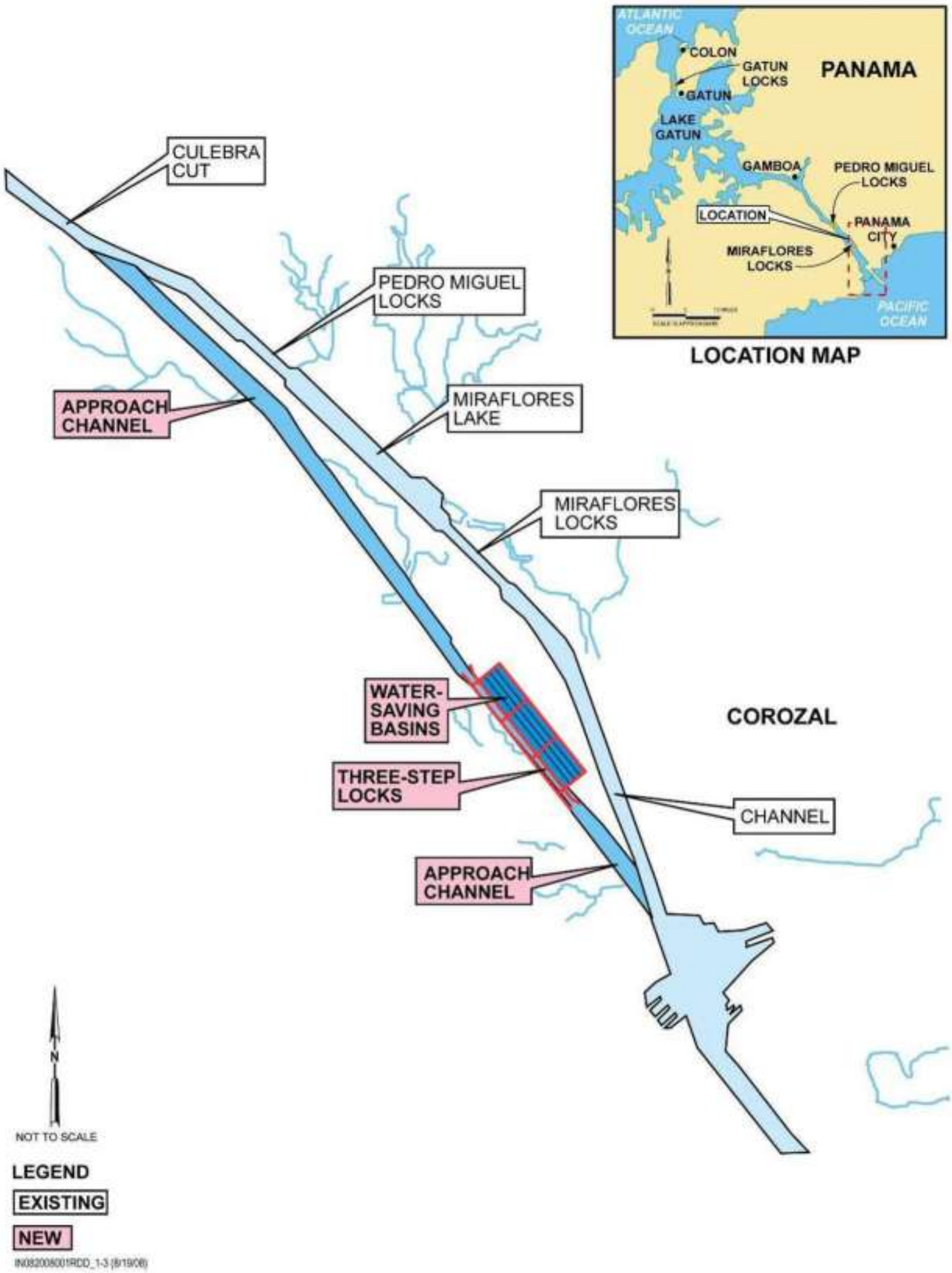
Water Supply Improvement Program (Rising of the Gatun Lake Maximum Operation Level) is also included in the PCEP. This subprogram encompasses the work required to raise the maximum operating level of Gatun Lake by 0.45 meter in order to augment the water supply for the expanded Panama Canal. This includes necessary improvements to prepare the infrastructure around the lake, including raising of the Gatun Spillway Gates and the Pedro Miguel and Gatun Locks Miter Gates affected. It also includes the development and implementation of a socioenvironmental-management plan for the lake.

The new locks and channels will form a navigation system which will be integrated into the existing locks and channels system. The two lanes that comprise the existing Panama Canal lock system will continue to operate during and after construction of the third-lane locks.

Program Location

The figures that follow illustrate the two distinct lock facilities – one on the Atlantic Ocean side of the isthmus and the other on the Pacific Ocean side – and their interface through the Culebra Cut (Gaillard Cut) and Gatun Lake. Both locks facilities will be located within the operational area of the ACP, adjacent to the existing locks. A lock facility will be located at the Atlantic end of the Canal, on the east side of Gatun Locks. The other facility will be located at the Pacific end of the Canal, to the southwest side of Miraflores Locks. The new locks will use a significant portion of excavation started by the United States in 1939 to build a third set of locks. The new locks will be connected to the existing channel system through new navigational channels.


ATLANTIC OCEAN
COLON
GATUN LOCKS
PANAMA
GATUN
LAKE GATUN
LOCATION
GAMBOA
PEDRO MIGUEL LOCKS
PANAMA CITY
MIRAFLORES LOCKS
PACIFIC OCEAN
LOCATION MAP
ATLANTIC OCEAN
CHANNEL
APPROACH CHANNEL
NOT TO SCALE
LEGEND
EXISTING
NEW
GATUN LOCKS
THREE-STEP LOCKS
WATER-SAVING BASINS
GATUN DAM
GATUN LAKE


ATLANTIC OCEAN
COLON
GATUN LOCKS
PANAMA
GATUN
LAKE GATUN
GAMBOA
PEDRO MIGUEL LOCKS
LOCATION
PANAMA CITY
MIRAFLORES LOCKS
PACIFIC OCEAN
LOCATION MAP
CULEBRA CUT
PEDRO MIGUEL LOCKS
APPROACH CHANNEL
MIRAFLORES LAKE
MIRAFLORES LOCKS
WATER-SAVING BASINS
COROZAL
THREE-STEP LOCKS
CHANNEL
APPROACH CHANNEL
N
NOT TO SCALE
LEGEND
EXISTING
NEW

Contractor Selection

Following the completion of a series of studies conducted both by in-house experts and foreign and local consultants, the Panama Canal Authority (ACP) presented the nation on April 13, 2006 with a proposal to expand the Canal through the construction of a Third Set of Locks. By legal mandate, a national referendum was ordered and, on October 22, 2006, Panamanians cast their vote approving the proposal by a large majority.

From that moment, the ACP assumed the responsibility of leading and executing the nation’s most extensive and comprehensive engineering feat in its history, with the express commitment of absolute transparency throughout the entire process.

The Canal Expansion Program was divided into different projects including a myriad of activities, among them dry excavation and dredging works to build the new navigation channels and accomplish widening and deepening in specific areas; environmental management; legal and financial consultancy; and the most extensive and comprehensive project of them all – the Design and Construction of the Third Set of Locks – the two structures that would enable the passage of post-Panamax vessels from one ocean to the other through Panama.

SELECTION OF NON-NEGOTIATED BEST-VALUE PROPOSAL

	55%	40%		5%			45%	100%	
Pre-qualified Tenderers	Points Technical Proposal Max. 5,500	Base Price Proposal	Points Base Price Max. 4,000	Provisional Sum Price Proposal	Points Provisional Sum Max. 500	Total Price Proposal	Total Points Price Proposal Max. 4,500	Total Points Max. 10,000	Best Value Proposal
Bechtel, Taisei, Mitsubishi Corporation	3789.5	$4,185,983,000.00	2980.3	$93,836,670.00	n/a	$4,279,819,670.00	2980.3	6769.8	2
Consorcio C.A.N.A.L.	3973.5	$5,981,020,333.00	2085.9	$	500	$5,981,020,333.00	2585.9	6559.4	3
Grupo Unidos por el Canal	4088.5	$3,118,880,001.00	4000.0	$102,751,383.00	n/a	$3,221,631,384.00	4000.0	8088.5	1
ACP - Amount of Allotted Funds		$3,481,000,000.00							

The Tender submitted by Grupo Unidos por el Canal (GUPC), identified with the color green, obtained the highest technical score with 4088.5 points. Upon opening the envelopes with the Price Proposals during the ceremony, the consortium, with a Price Proposal of $3,221,631,384.00, including the provisional sum (please see detailed price proposal at the end of this document), was officially selected as the Tenderer with the non-negotiated best value proposal. The provisional sum includes the cost of additional works that complement the construction of the Third Set of Locks, which are the construction of lock approach structures and maintenance. ACP's Amount of Allotted Funds for the project totaled $3,481,000,000.00. When assessing the Price Proposals, the maximum score was awarded to the proposal with the lowest price and the lowest provisional sum. The second bidder, led by Bechtel, was over $1 billion higher than the low bidder.

ITEM	DATE
Letter of Acceptance	15-Jul-2009
Issue of Order to Commence	18-Aug-2009
Commencement	25-Aug-2009
Post Award Conference	22-Sep-2009
Design Kick-Off Conference	1-Oct-2009
Time for Completion	1,883 Days after Commencement
Original Date of Completion	20-Oct-2014
Date of Completion per MU-27 Programme	20-Apr-2015
Advance Payment for Mobilization	15-Jan-2010
Advance Payment for Plant #1	20-Sep-2010
Advance Payment for Plant #2	19-Jan-2011

Table 1-2 Key Dates

CONTRACT	DESIGN & CONSTRUCTION of the THIRD SET OF LOCKS PROJECT
Employer	**AUTORIADAD del CANAL de PANAMA**
Contract Number	CMC-221427
Base Contract Amount	$3,118,880,001.00
Provisional Sums	$79,620,058.00
Material Price Adjustments	$118,569,334.10
Legislation Price Adjustments	$21,081,716.16
Labor Rate Adjustments	$19,391,983.45
DAB Fees	$1,305,222.79
ACP Invoices for Pilotage	($4,780,568.60)
Employer's Variations	($1,574,867.71)
Contractor's Claims Awarded	$19,049,498.40
Interest Charges for Advance Payment for Steel	($236,799.12)
Interest Charges for Moratorium on Repayment of Advance Payments	($2,850,177.44)
Total Contract Amount	**$3,368,455,401.03**

Table 1-1 Contract Amount

MODULE E - EXPANSION PROJECT PROGRESS

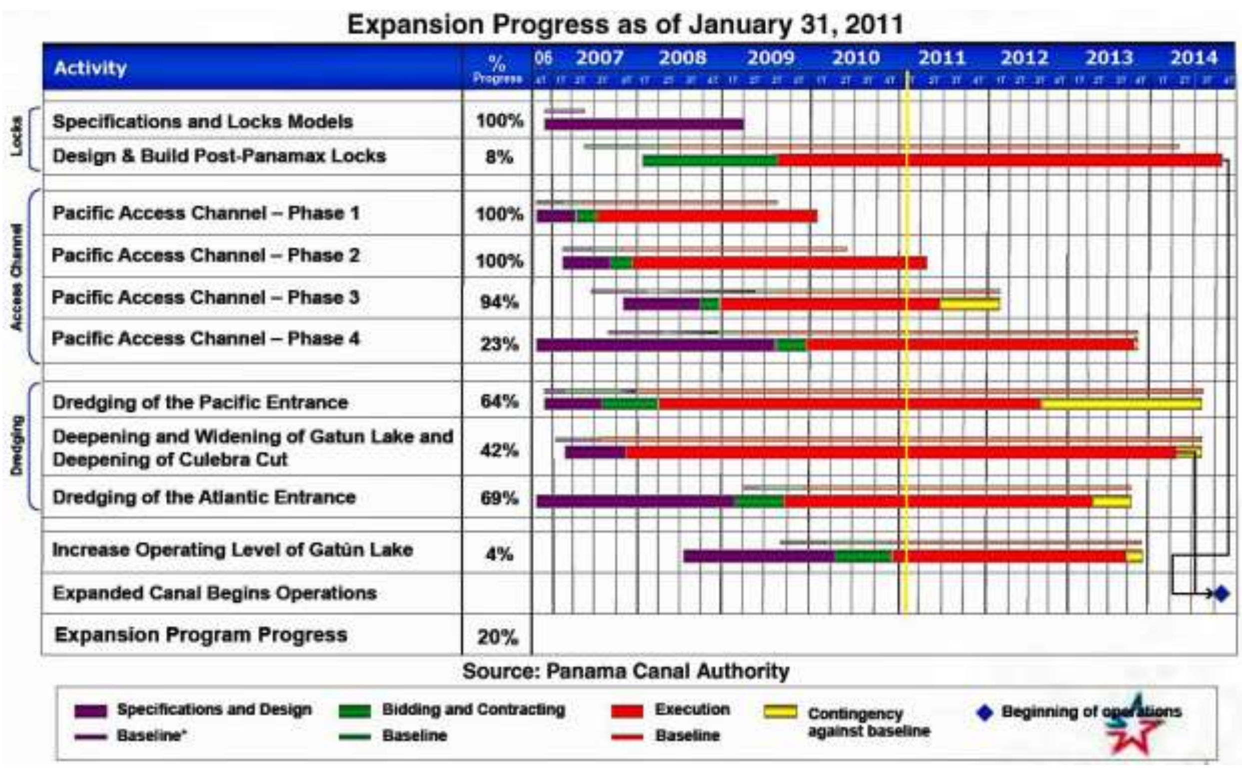
Expansion Project Execution

Current Completion Status as of July 31, 2014

According to ACP, the progress obtained for each major component of the expansion project is as follows:

Atlantic Entrance Dredging	100%
Pacific Entrance Dredging	100%
Raising Gatun Lake's Maximum Operating Level	90%
Gatun Lake and Culebra cut Dredging	84%
Pacific Access Channel	79%
Design and Construction of the Third Set of Locks	71%

The original Plan for the above work is shown in the schedule below which indicates an overall completion time in late 2014.



The budget over budget for the expansion project is $5.2 billion with over 60% of that dedicated to the Third Set of Locks component. The remainder of the execution and progress information below is dedicated to the third set of locks component for which a detailed progress study was performed in February 2014.

Third Set of Locks Contractor

Grupo Unidos por el Canal, SA (GUPC SA) is the contractor responsible for the design and construction of the Third Set of Locks - main project of the Canal Expansion Program.

GUPC is led by Sacyr Vallehermoso of Spain alongside Impregilo of Italy, Jan De Nul of Belgium and Constructura Urbana, SA (CUSA) of Panama.

The major subcontractors of GUPC SA is as follows:

1. Montgomery Watson Harza-Design
2. CICP Consultores Internacionales-Design
3. Cimolai-Lock Gates
4. Hyundai-Locks and Water Saving Basin Valves

CIVIL WORKS QUANTITIES							
ATLANTIC SITE				PACIFIC SITE			
Dredging	6,670,242 M3	Reinforcing Steel	84,922 T	Dredging	4,514,586 M3	Reinforcing Steel	107,089 T
Excavation	17,972,907 M3	Cement	570,620 T	Excavation (Ex. Basalt)	19,198,992 M3	Cement	617,538 T
Fill (Excluding Filters)	2,032,345 M3	Coarse Agregates	2,530,195 T	Fill (Excluding Filters)	19,192,950 M3	Coarse Agregates	3,019,538 T
Filters	140,514 M3	Fine Aggregates	1,922,081 T	Filters	560,778 M3	Fine Aggregates	2,067,557 T
Concrete	2,064,627 M3			Concrete	2,375,119 M3	Excavation (Basalt)*	4,138,473 M3

MAIN EQUIPMENT							
ATLANTIC SITE				PACIFIC SITE			
Lock Gates	8 Units	Equalization Valves	8 Units	Lock Gates	8 Units	Equalization Valves	8 Units
Culvert Valves	32 Units	Control Buildings	32 Units	Culvert Valves	32 Units	Control Buildings	32 Units
Conduit Valves (WSB)	36 Units			Conduit Valves (WSB)	36 Units		

Key Project Dates

Letter of Acceptance	Jul.15, 2009
Order of Commence	Aug.18, 2009
Commencement Date	Aug.25, 2009
Post Award Conference	Sep.22, 2009
Design Kick-Off conference	Oct.01, 2009
Time for Completion - Days after Commencement Date	1,883
Date of Completion - Accepted Baseline Schedule *(Aprov. Feb. 2010)*	Oct.21, 2014
Date of Completion - MU 44 Programme *(Subm. Sep. 2013)*	Jun.30, 2015
(Expected total entitlement to Extension of Time is at least 500 days)	-

Critical Path

The detailed schedule maintained by the contractor has over 12,000 activities in it. The Atlantic critical path is being driven by the installation of Concrete in the Lock Head 4, which in turn pushes the necessary works for the installation of the Gates 7 and 8, the start of the flooding, the commissioning of the rest of gates and the interconnection of the Control and Back up Control Building with all the systems needed for the Operational Test and Performance Test.

For the Pacific site several Critical Paths have been identified.

The concrete activities in the Lower Chamber, both east and west side, are driving the backfill activities and the construction of the WSB Machinery Room Building 5 and Machinery Room Building 8, the installation of the fiber optics in both buildings pushes the interconnection of the Control and Back up Control Building with all the systems needed for the Operational and Performance Tests.

As with the Lower Chamber, the concrete activities in the Middle Chamber east side, pushes the backfill and the construction of the WSB Machinery Room Building 4, which installation of fiber optics is also pushing the interconnection of the Control and Back up Control Building with all the systems needed for the

Operational Test and Performance Test.

The concrete activities in the Outlet Wing Wall are driving the installation of the second stage embeds and guides and then the installation and test of the Bulkheads, which is in turn driving the end of tests before the start of the flooding.

The transport of gates into the recess and the completion of the gates installation works are driving the start of the flooding.

Finally, for both sites, the contractor is monitoring the productivity of the installation of second stage embedded parts that could affect the flooding date.

Budgeted Value of the Work

Activity	Current Budget	%
SITE DEVELOPMENT	$ 148,888,000	**5%**
DESIGN	$ 223,280,978	**7%**
Excavation	$ 261,661,696	**8%**
Fills	$ 91,430,834	**3%**
Dredging	$ 78,381,365	**2%**
Dams	$ 70,489,711	**2%**
Concrete	$ 844,889,623	**26%**
Rebar	$ 195,444,740	**6%**
Lock Valves and Bulkheads	$ 146,725,785	**5%**
WSB Valves and Bulkheads	$ 118,345,038	**4%**
Gates and Recess Closures	$ 552,346,211	**17%**
Plant Mechanical Systems and Eq.	$ 70,063,635	**2%**
Electrical Eq.	$ 89,974,331	**3%**
Instrumentation and Controls	$ 49,607,522	**2%**
Locks Appurtenances	$ 51,756,939	**2%**
Sitework	$ 53,331,518	**2%**
Buildings	$ 57,064,675	**2%**
Utilities	$ 15,197,400	**0%**
Provisional Sums	$ 79,620,058	**2%**
TOTAL	$3,198,500,060	

The largest portion of the project includes the gates, valves and lock appurtenances which comprises 43% of the budgeted value. Concrete work represents nearly a third of the work. The remaining 25% of the work includes earthwork (12%) and MEP, site work, buildings and utilities.

Progress Photos-Feb. 2014

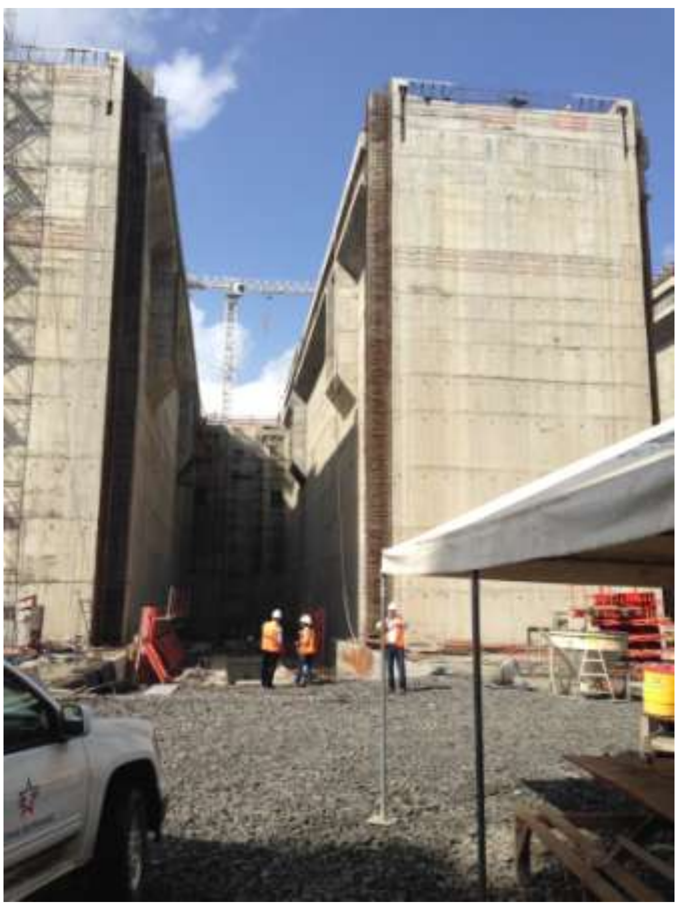
The photo above looking into the Pacific Locks from the South to North exemplifies the complex nature of the work. There at 20 tower cranes in place on both the Pacific and Atlantic lock construction sites.

Existing Miraflores lock structure with Borinquen Dam on right

Atlantic Site looking South through the canal chambers

Pacific Aggregate Crushing Plant

Lock Head structure that receives sliding gate



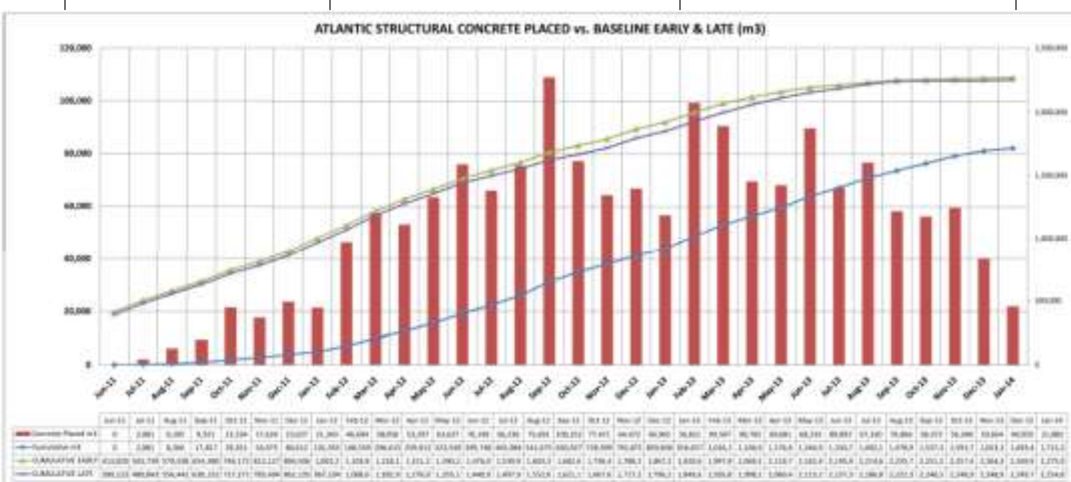
Sliding Gate in laydown on site

Deliver of lock gates to site laydown area

Expansion Project Status by Discipline-as of Feb 5, 2014

Description	Construction Completion Status	Design Completion Status
Atlantic		
Excavation	79%	100%
Backfill	29%	100%
Concrete	86%	90%
Gates	50%	100%
Valves	82%	100%
Mechanical	13%	60%
Electrical	44%	80%
I&C	0%	20%
Buildings	7%	85%
Site Work	11%	96%

Description	Construction Completion Status	Design Completion Status
Pacific		
Excavation	83%	100%
Backfill	51%	100%
Concrete	80%	93%
Dams	51%	100%
Gates	47%	100%
Valves	80%	100%
Mechanical	10%	100%
Electrical	44%	80%
I&C	0%	20%
Buildings	7%	85%
Site Work	11%	96%
Overall Project	**65%**	**85%**



Graph 1-10 Atlantic Concrete Progress vs. Baseline

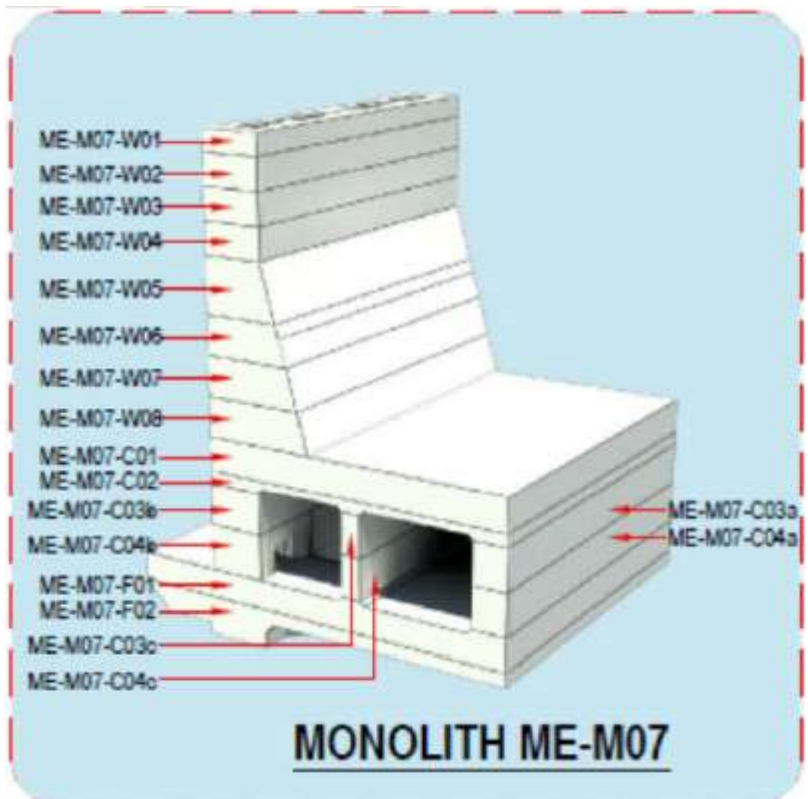
Graph 1-12 Pacific Concrete Progress vs. Baseline

Atlantic Construction Activities-EXCAVATION			
Activity Name	**GUPC Jan. Billing Foreseen Quantity**	**GUPC Jan. Billing To Date Quantity**	**% Complete**
Excavation			
A_Site: Clear, Grub and Strip 4c Locks Upper Chamber (LUC) (Contractor's Resu			100.00%
A_Ocean Entr: Remove Dam	91,298	15,137	16.58%
A_Gatun Entr: Remove Plug	250,000		0.00%
A_Entrance/Ocean WW: Perform Excavation Wing	587,606	578,926	98.52%
A_LH4: Perform Excavation WS	339,727	339,727	100.00%
A_LLC: Perform Bulk Excavation WS	1,289,638	1,288,794	99.93%
A_LH3: Perform Excavation WS	343,519	343,519	100.00%
A_LMC: Perform Excavation WS	1,383,705	1,383,705	100.00%
A_LH2: Perform Excavation WS	216,260	216,260	100.00%
A_LUC: Perform Excavation WS	1,323,970	1,323,970	100.00%
A_LH1: Perform Bulk Excavation WS	313,157	313,157	100.00%
A_Gatun WW: Perform Excavation Wing Walls and	1,135,104	415,789	36.63%
A_WSB-LC: Perform Excavation WS	3,259,561	3,070,672	94.21%
A_WSB-MC: Perform Excavation WS	3,268,024	3,015,138	92.26%
A_WSB-UC: Perform Excavation WS	3,916,481	3,753,937	95.85%
A_ZC: Perform Slope Support & Excavation Finishing WS		-	0.00%
A_Gatun WW Cutoff Wall: Build Gatun Cut-off Wall WS			100.00%
TOTAL DRY EXCAVATION	**17,718,050**	**16,058,731**	**90.63%**
Dredging			
A_Ocean Entr: Excavate/Dredge Channel WS	6,420,242	3,324,705	51.78%
TOTAL DREDGING	**6,420,242**	**3,324,705**	**51.78%**
TOTAL EXCAVATION	**24,138,292**	**19,383,436**	**80.30%**

Pacific Construciton Activity-Dams			
Activity Name	PMT Foreseen Quantity	PMT to date Feb 5 Quantity	Physical % Complete
P_Dam 2E: Excavate Embankment Foundation WS	3,252,443	3,115,265	95.78%
P_Dam 2E: Drilling and Grout Curtain - Phase 1 WS	1,047	838	80.04%
P_Dam 2E: Embankment WS	3,875,481	1,335,861	34.47%
P_Dam 2E: Drilling and Grout Curtain - Phase 2 WS			
P_Dam 1W: Excavate Embankment Foundation WS	565,733	564,358	99.76%
P_Dam 1W: Drilling and Grout Curtain WS	488	488	100.00%
P_Dam 1W: Embankment WS	815,369	440,495	54.02%
P_Dam 2W: Excavate Embankment Foundation WS	1,856,856	1,310,989	70.60%
P_Dam 2W: Drilling and Grout Curtain WS	1,101	322	29.25%
P_Dam 2W: Embankment WS	2,215,785	209,997	9.48%
LOE P_Dam2E, 1W, 2W: Backfill all Dams (DAM 2E, 1W, 2W)	2,274,049	629,278	27.67%
TOTAL DAM EARTHWORK (m3)	**14,855,716**	**7,606,243**	**51.20%**

Atlantic Construcion Activity-Concrete			
Activity Name	PMT Foreseen Quantity	PMT to date Feb 5 Quantity	Physical % Complete
A_Entrance/Ocean WW: Install Concrete Wing Walls WS	87,622	60,445	68.98%
A_LH4: Install Concrete WS	148,021	141,523	95.61%
A_LLC: Install Concrete WS	321,121	309,522	96.39%
A_LLC: Install Duct Bank (LH4 Mach. Room Bldg. to LH3 Mach. Room Bldg.	6,000		0.00%
A_LH3: Install Concrete WS	148,299	147,313	99.34%
A_LMC: Install Concrete WS	312,045	308,751	98.94%
A_LMC: Install Duct Bank (LH3 Mach. Room Bldg. to LH2 Mach. Room Bldg.	6,000		0.00%
A_LH2: Install Concrete WS	150,109	148,202	98.73%
A_LUC: Install Concrete WS	333,201	328,016	98.44%
A_LUC: Install Duct Bank (LH2 Mach. Room Bldg. to LH1 Mach. Room Bldg.	6,000		0.00%
A_LH1: Install Concrete WS	120,671	119,206	98.79%
A_Gatun WW: Install Concrete Wing Walls WS	85,616	36,491	42.62%
A_WSB-LC: Install Concrete Walls, Conduits, Trifurcation, Valve Structure,	93,700	35,161	37.53%
A_WSB-MC: Install Concrete Walls, Conduits, Trifurcation, Valve Structure	92,079	28,233	30.66%
A_WSB-UC: Install Concrete Walls, Conduits, Trifurcation, Valve Structure,	95,999	60,573	63.10%
TOTAL CONCRETE-ATLANTIC	**2,006,483**	**1,723,436**	**85.89%**

When the concrete design of a structure is issued as released for construction, both GUPC and ACP agree on the quantity of concrete work (m3) for each lift (pour) that will be made to complete the structure. The lift for each structure is also referred to as a Unit of Measure (UOM). This agreed UOM quantity is the design quantity that is used throughout the project to measure progress and approve pay applications. Below is an example of one of the monolith structures (M07) that forms the lock structure wall in the middle chamber which shows each UOM designated as ME-M07-XXX.



MONOLITH M07				
UOM			STEEL (Ton)	VOLUME (m3)
LE	M07	W01	1.89	119
LE	M07	W02	3.10	195
LE	M07	W03b	3.24	204
LE	M07	W03a	3.24	204
LE	M07	W04	4.89	308
LE	M07	W05	5.96	375
LE	M07	W06	7.00	441
LE	M07	W07	8.08	509
LE	M07	C01	57.59	1,295
LE	M07	C02	17.03	383
LE	M07	C03	4.94	111
LE	M07	C03	11.25	253
LE	M07	C03	6.58	148
LE	M07	C04c	4.76	107
LE	M07	C04b	10.01	225
LE	M07	C04a	6.00	135
LE	M07	F01	61.93	1,026
LE	M07	F02	58.25	965
MPLETED L	17		273.86	6,884

The significant concrete structures on the project are listed below.

- Lockhead 1(LH1)
- Lockhead 2(LH2)
- Lockhead 3(LH3)
- Lockhead 4(LH4)
- Upper Chamber
- Middle Chamber
- Lower Chamber
- Water Saving Basin-Upper (WSB)
- Water Saving Basin - Middle
- Water Saving Basin - Lower
- Inlet Wing Walls
- Outlet Wing Walls

Examples of the status of these concrete structures are shown as follows.

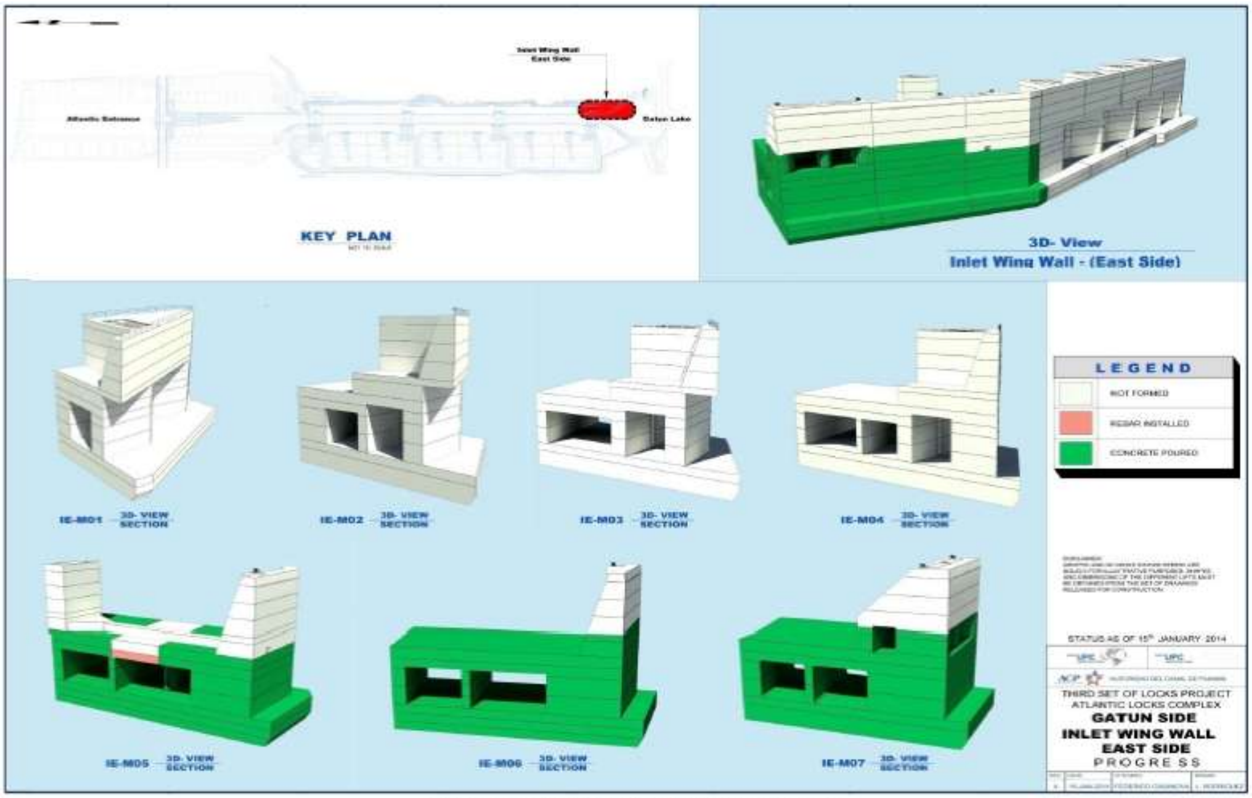


Figure 3-2 Inlet Wing Wall East Side - Progress

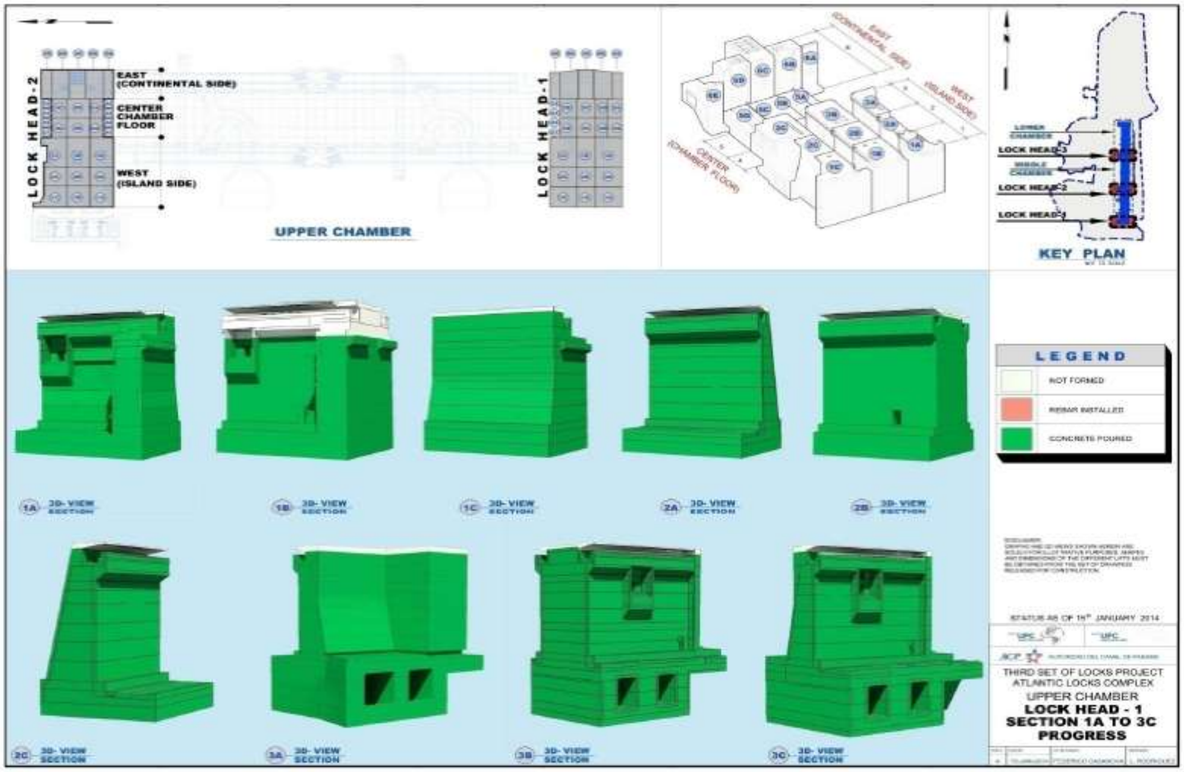
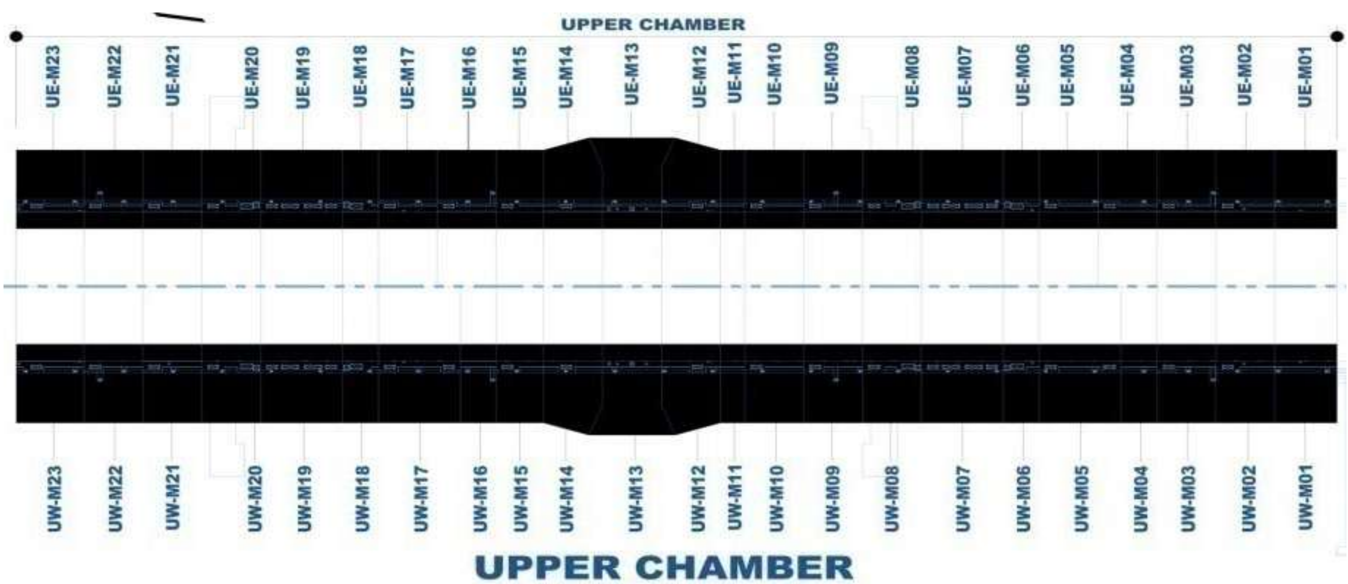


Figure 3-4 Lock Head 1 Section 1A to 3C



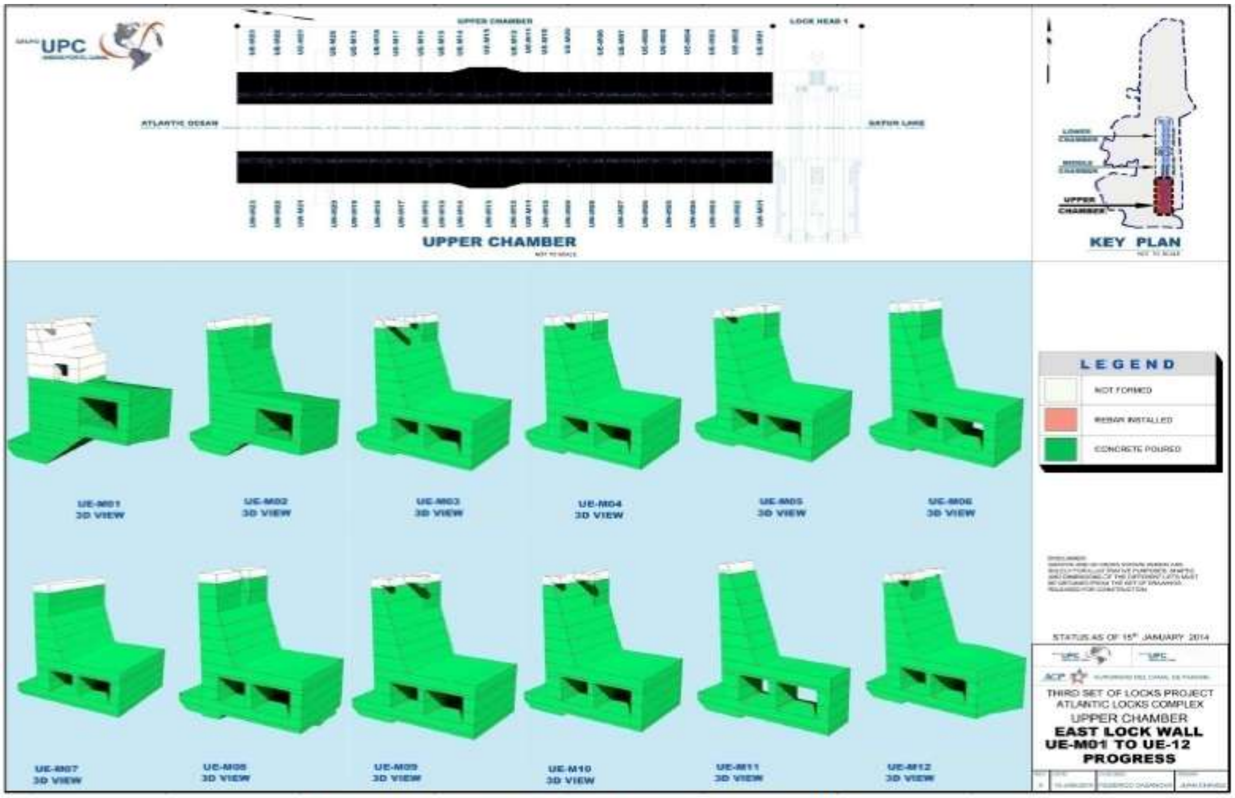


Figure 3-6 Upper Chamber East Lock Wall UE-M01 to M12 Progress

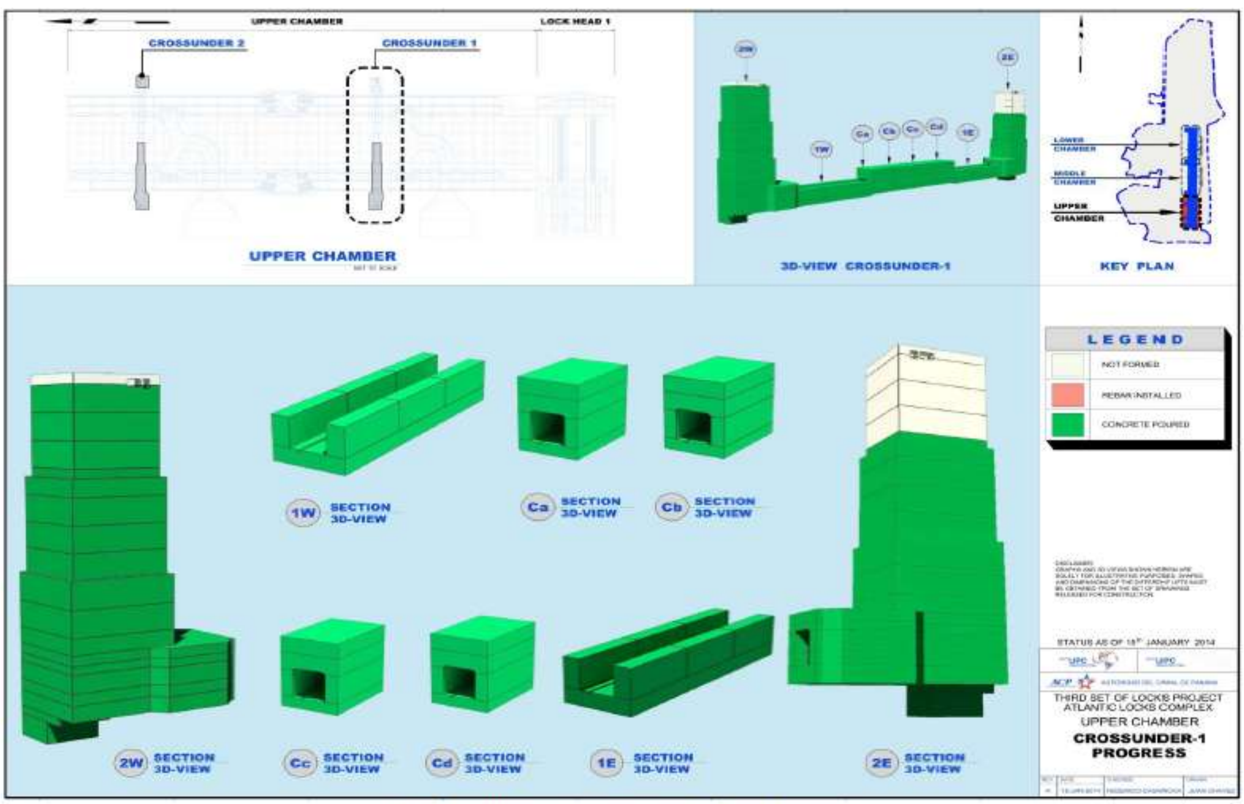


Figure 3-10 Upper Chamber Crossunder-1 Progress

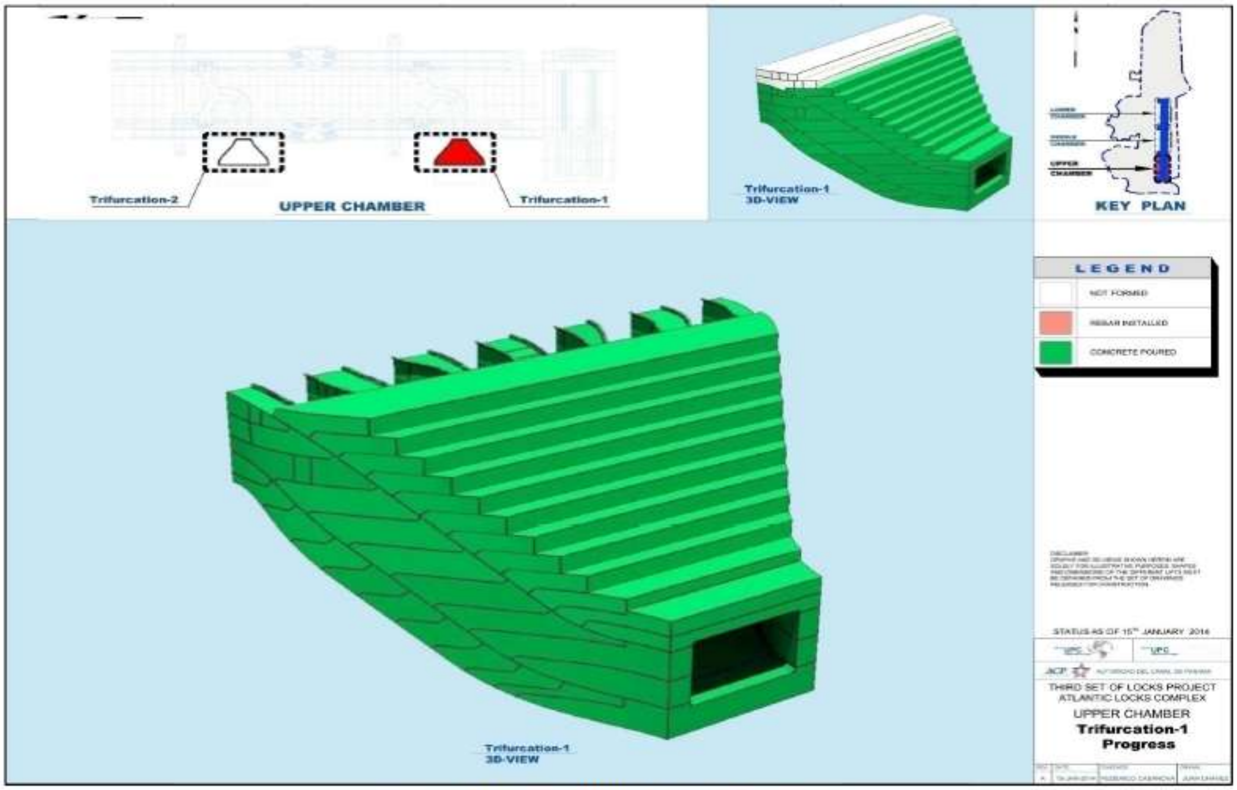


Figure 3-12 Upper Chamber Trifurcation 1 Progress

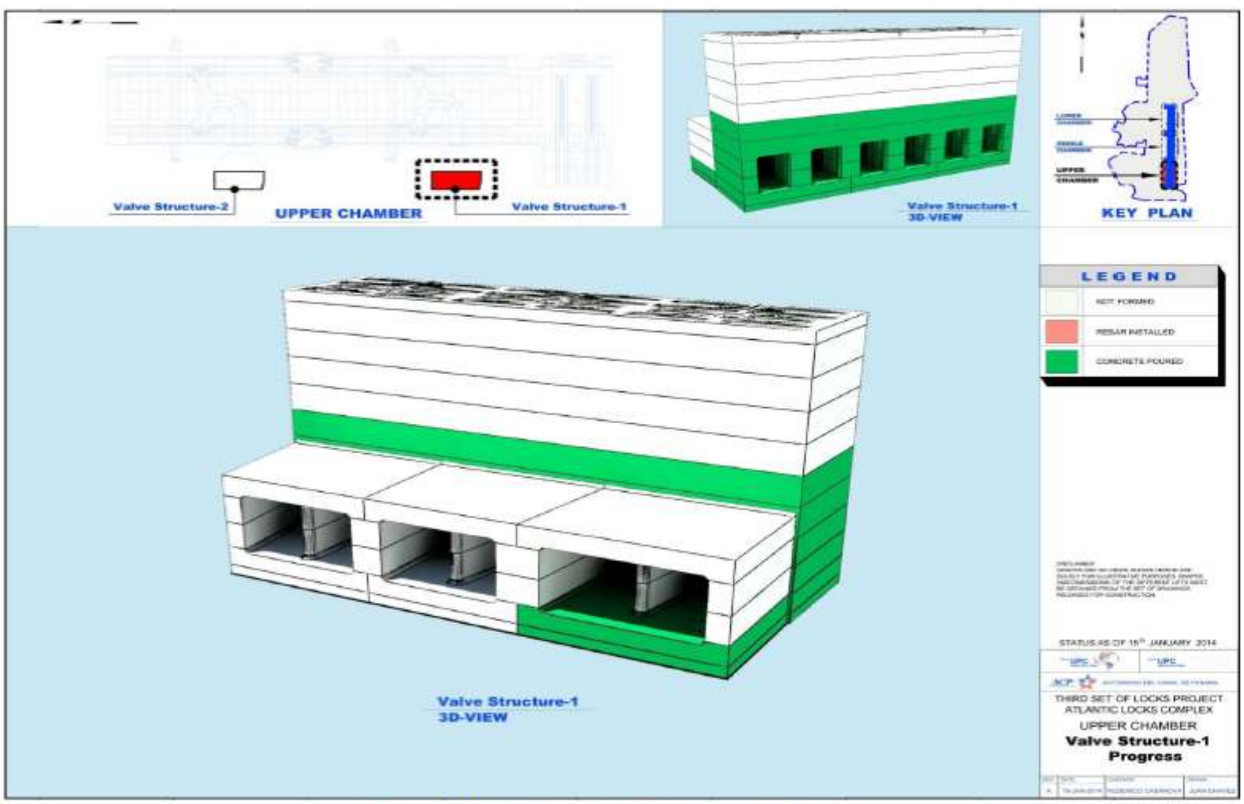


Figure 3-14 Upper Chamber Valve Structure 1 Progress

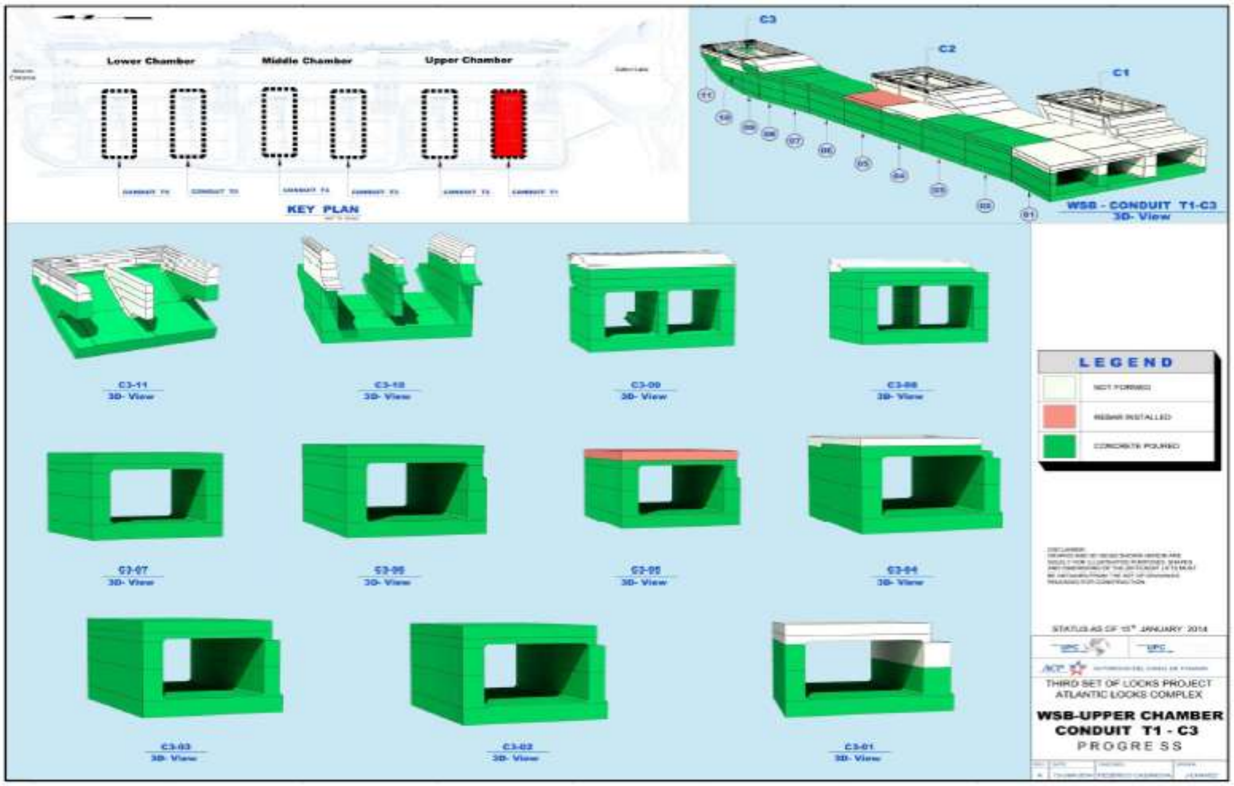


Figure 3-18 Upper Chamber - WSB Conduit T1- C3 Progress

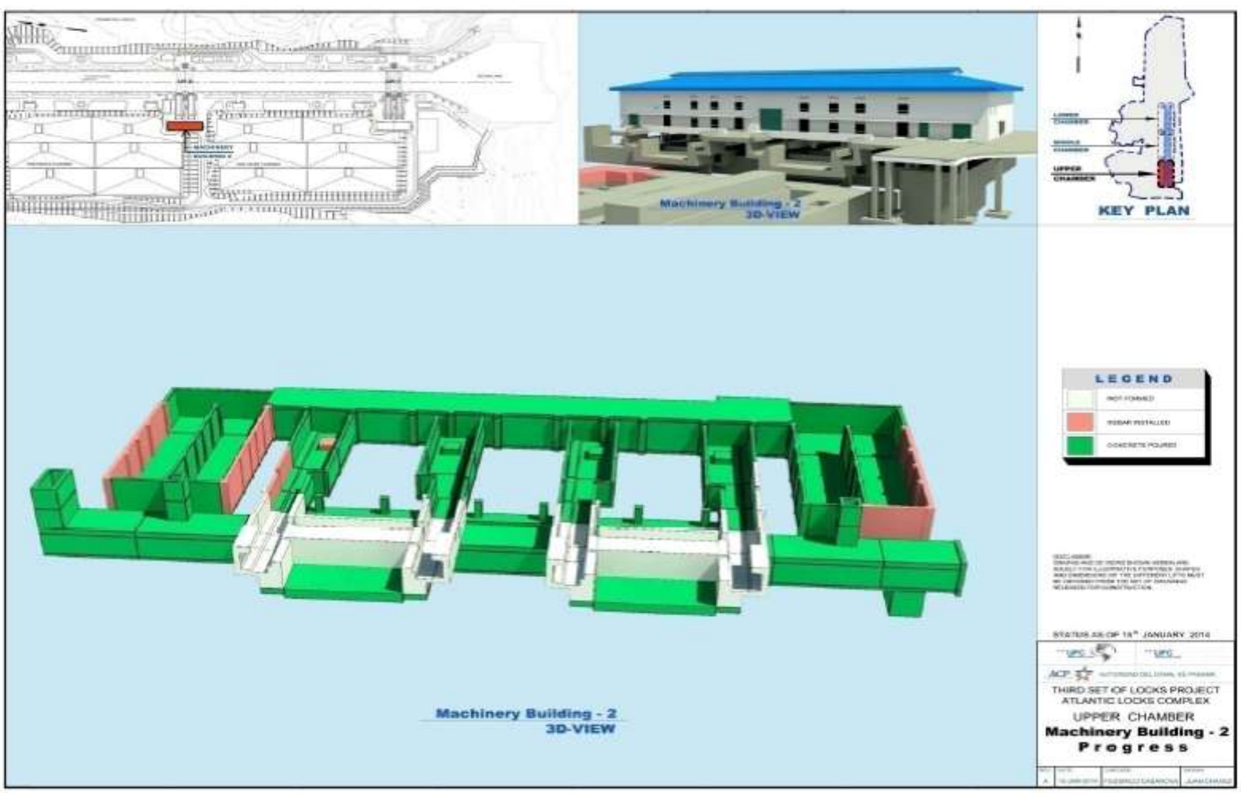


Figure 3-23 Upper Chamber - Machinery Building 2 Progress

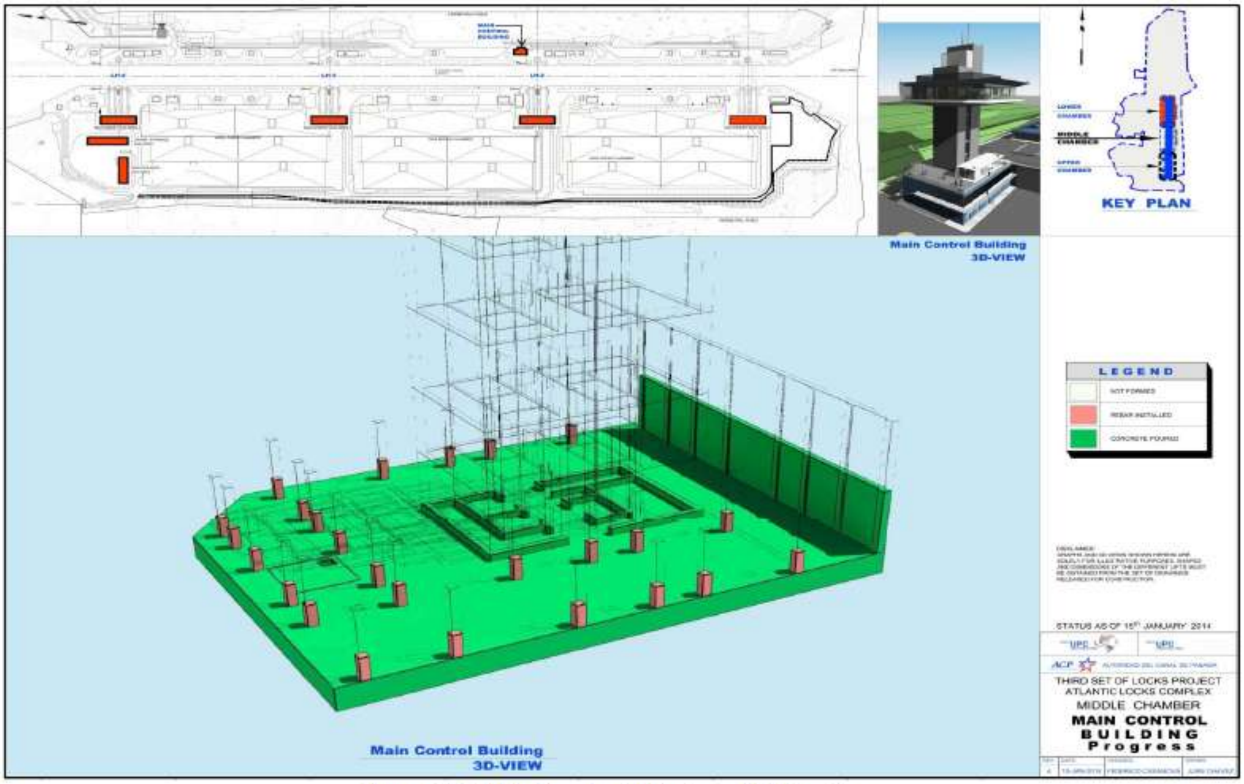


Figure 3-37 Middle Chamber - Main Control Building Progress

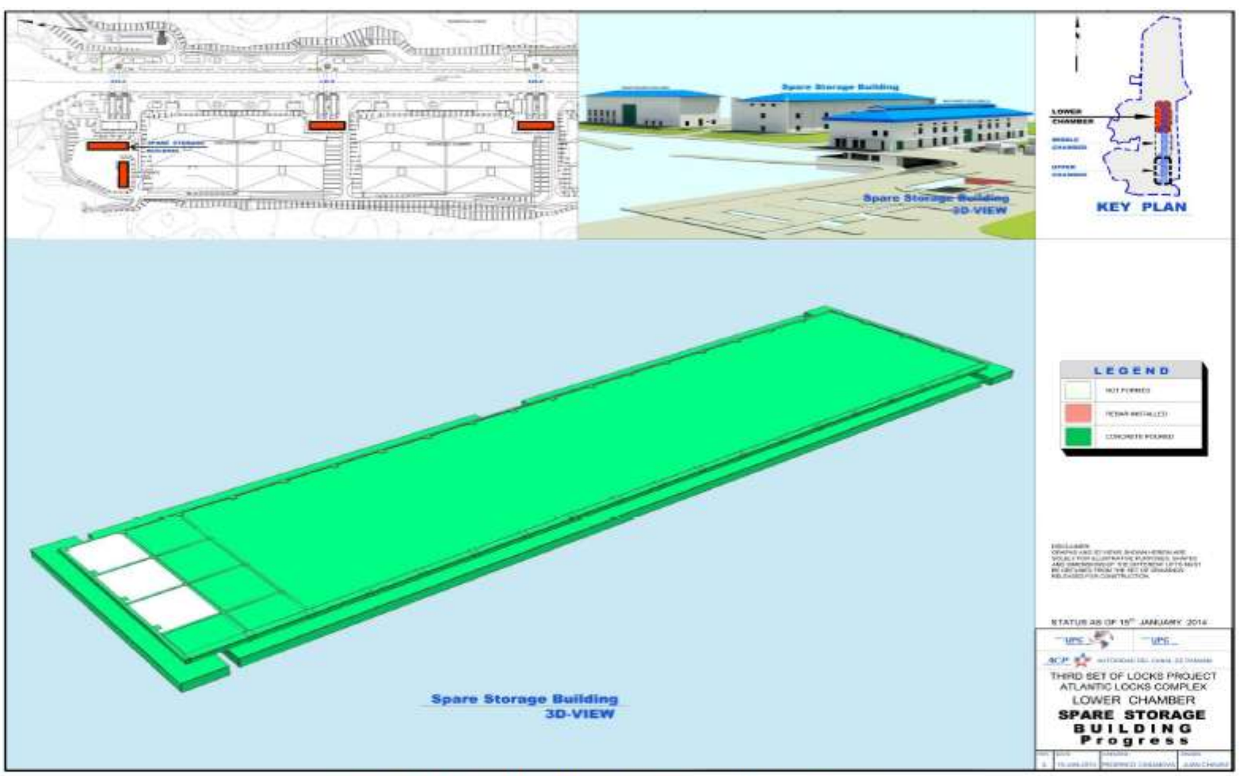


Figure 3-54 Lower Chamber - Spare Storage Building Progress

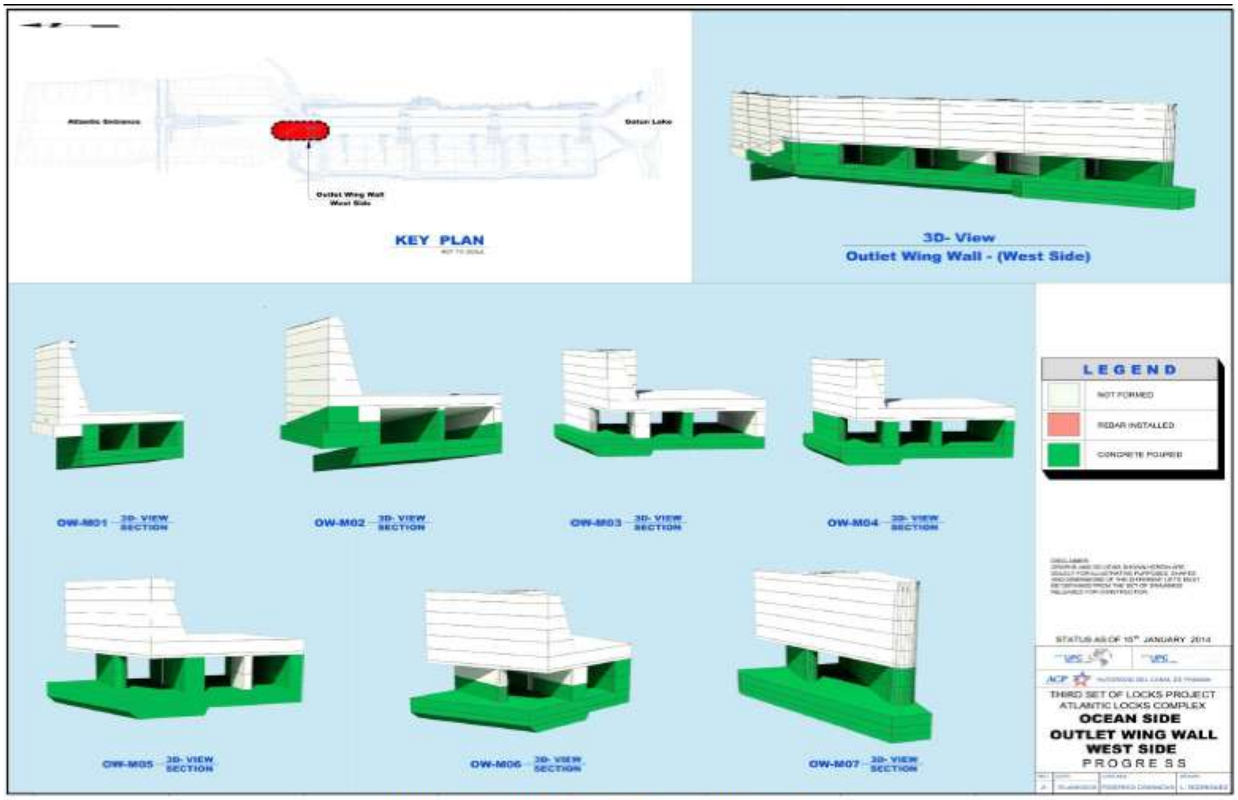
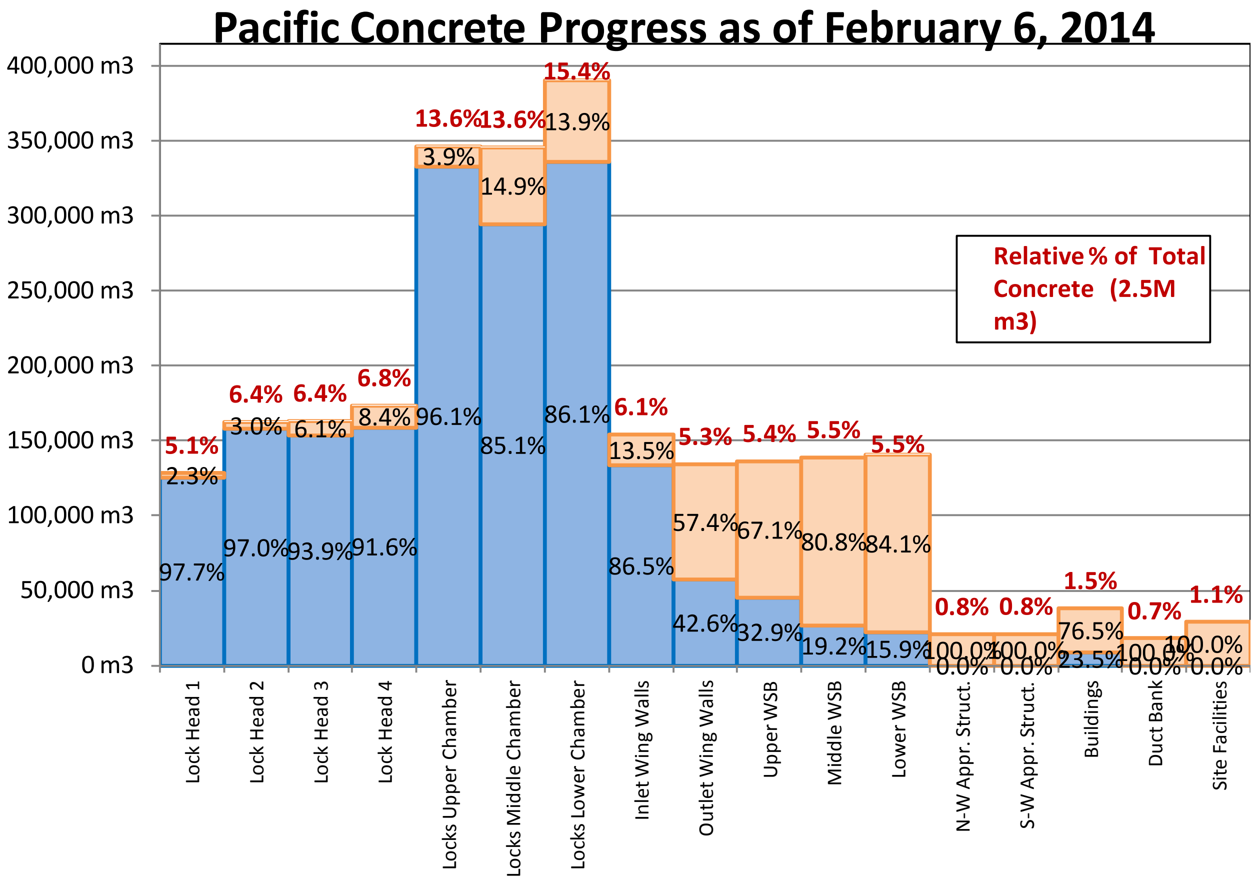
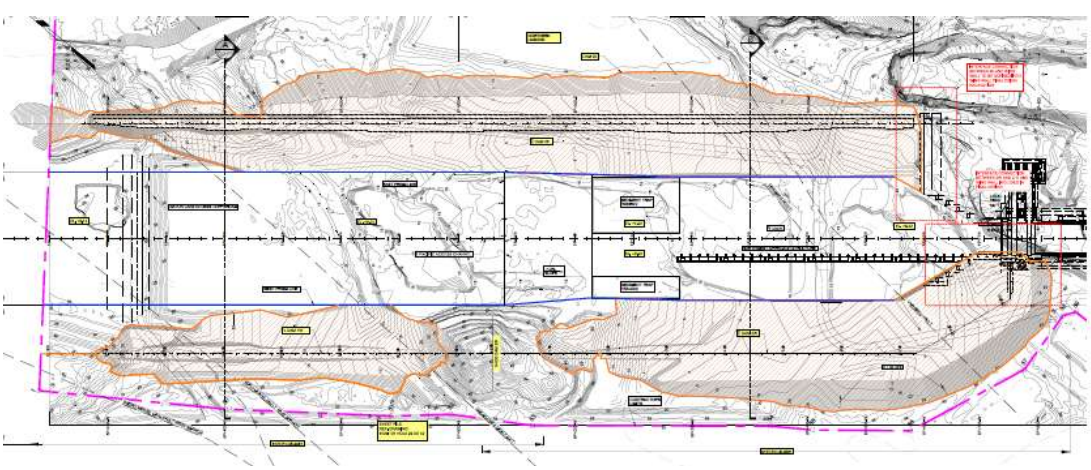


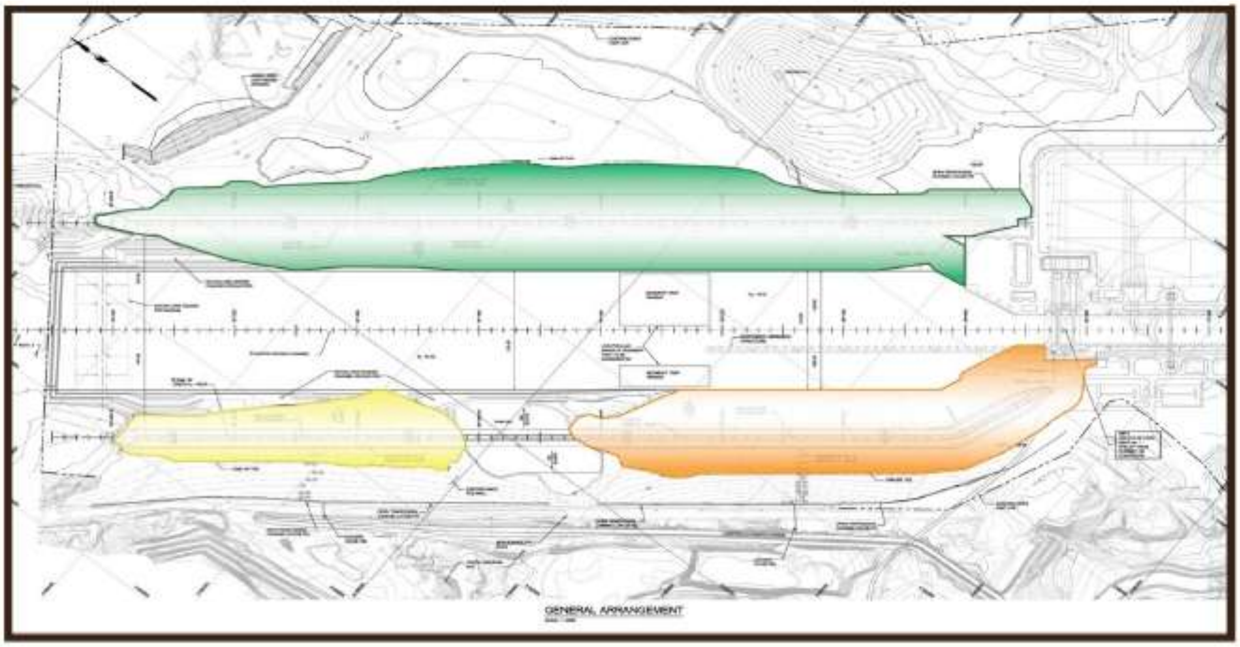
Figure 3-60 Outlet Wing Wall West Side - Progress



Borinquen Dam

The Panama Canal Third set of Locks Project scope includes the construction of a portion of the Borinquen Dams north of the Pacific lock structure. The Borinquen Dam work under this contract includes the 1W dam, 2E Dam, and the 2W dam. These three dam areas involve 5.7 million m3 of excavation and 7 million m3 backfill. The drawing below depicts the dams with Dam 2E on the top of the drawing, Dam 1W on the lower left and Dam 2W on the lower right of the drawing. The relative length of each Dam 2Eis 1390 meters.





Dam 2E
Inject Grout Borinquen Phase 1
Up to January 2014
81.61%

Dam 2W
Inject Grout
Up to January 2014
45.51%

Dam 1W
Backfill Embankment
Up to January 2014
54.54%

Backfill of Dam 2E, 2W & 1W
Up to January 2014
35.61%

ACP reported that the GUPC dam subcontractor stopped work on November 25, 2013 due to payment issues between them and GUPC. Idle equipment from the work stoppage is shown here and below.

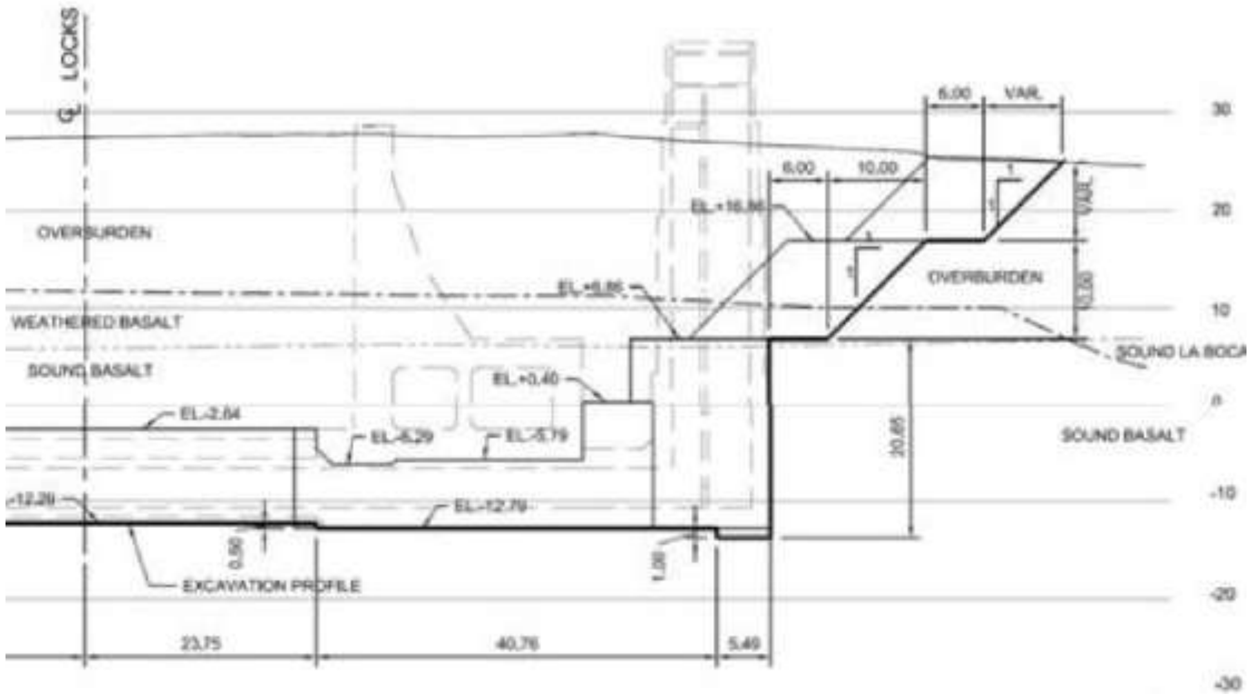
PHOTO PAC 52 - 87 Borinquen Dam 1W - Sector D6 to S

UPC Contract: CMC-221427 Design and Construction of the Third Set of Locks
MONTHLY PROGRESS REPORT No. 52 Date: 21-Jan-14
Doc: G00/UPCMPR0052-UA JANUARY 2014 - SECTION 12 Page: 205 of 232

UPC Contract: CMC-221427 Design and Construction of the Third Set of Locks
MONTHLY PROGRESS REPORT No. 52 Date: 21-Jan-14
Doc: G00/UPCMPR0052-UA JANUARY 2014 - SECTION 12 Page: 206 of 232

Earthwork

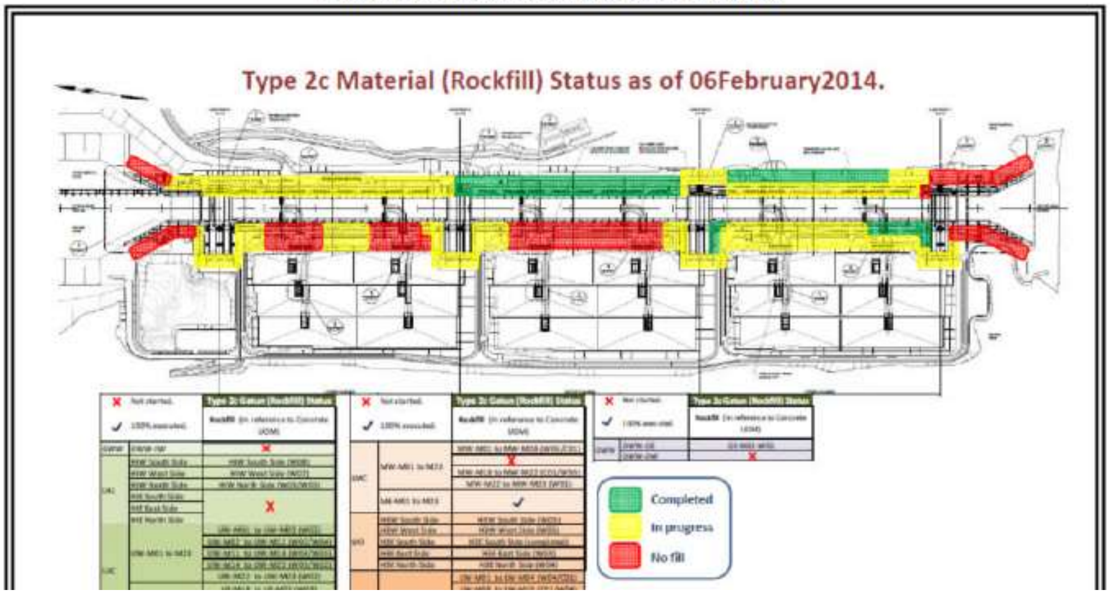
The excavation for the Project is mainly an open pit excavation and dredging operation in a studied and cleared geologic area. The Project does not involve underground or underwater construction work. Excavated basalt materials are used for concrete aggregate.



Lock Chamber Excavation Profile

The backfill for the Project is mainly the rockfill and earthfill behind structural elements that replace voids from the open pit excavation activities. The scope of the backfill areas are filling excavations and voids of approaches, locks, chambers, water saving basins, and dams.

Table A.2.5 - Rockfill Status as of 06 Feb 2014



Personnel on Site - Status as of November 24, 2013

Work Areas	Expatriate Staff	Panamanian Staff	Labor	Totals
Main Office	40	91	0	131
Atlantic Work Site	141	756	2,741	3,638
Pacific Work Site	194	839	2,678	3,711
Sub Total GUPC's employees	375	1,686	5,419	7,480
	5%	23%	72%	100%
Subcontractors and Services	425	230	2,387	3,042
Total General	800	1,916	7,807	10,523
	8%	18%	74%	100%

PAYMENTS (GUPC'S APPLICATIONS x ACP'S CERTIFICATES) - STATUS AS OF OCTOBER, 2013 - US$ MIO						
PAYMENT ITEMS	CONTRACT VALUE	GUPC's APPLICATIONS FOR PAYMENT		ACP's PAYMENT CERTIFICATES		DIFFERENCE NOT CERTIFIED (Back Log)
BASE CONTRACT VALUE	3,118.9	1,917.1	61.5%	1,888.5	60.6%	-28.6
PROVISIONAL SUMS	79.6	0.0		0.0		0.0
EMPLOYER'S VARIATIONS	-1.2	-1.2		-1.2		0.0
CONTRACTOR'S CLAIMS	17.6	666.4		16.3		-650.1
RETENTIONS (-3.5%)	0.0	-90.0		-66.6		23.4
OTHER ADDIT. AND DEDUCT.	-5.6	-3.3		-5.6		-2.3
ADJUSTMENTS FOR CHANGES	127.4	127.4		127.4		0.0
LABOR ESCALATION	12.2	12.2		12.2		0.0
TOTALS	3,348.9	2,628.6		1,971.0		-657.6

Financial commitments as of November 2013	US$
Payment Bond	50.0 Mio
Guarantee for Performance Bond	400.0 Mio
Letter of Credit for Advance Payments	548.0 Mio
Loan from Banks	40.0 Mio
Loan from Caterpillar	34.4 Mio
Financial contribution from Shareholders	218.0 Mio
Debt to Shareholders *(wages + premium of bonds as of Oct.31, 2013)*	76.7 Mio
Surety for Steel Price Adjustment	1.2 Mio
Shareholders Guarantee for Key Suppliers	68.1 Mio
Surety for Gates & Valves (Target up to 150.0 Mio)	128.0 Mio
Shareholders Comfort Letter for Specified Suppliers (150.0 Mio)	147.4 Mio
Total commitments to date	1,711.8 Mio

Cost Accounts Economical Balance - Status as of OCTOBER 2013	(US$ Mio)		
	As of Dec.2012	Jan... Oct. 2013	As of Oct. 2013
Base Contract Revenues *(Include Accruals)*	1,091.2	797.3	1,888.5
Variations, Claims & Determinations	0.6	14.5	15.1
Adjust. for Changes in Materials Prices and Labor Cl 13.9	103.8	35.8	139.6
Total Revenues	1,195.6	847.6	2,043.2
Local labor	278.2	169.1	447.3
Local staff	52.2	22.4	74.6
Expatriates staff	123.2	41.2	164.4
Materials	413.3	269.8	683.1
Depreciation	143.2	101.4	244.6
Subcontracts	352.9	388.4	741.3
Services	219.3	57.6	276.9
General expenses	133.5	43.3	176.8
Other services & Transports	34.2	18.0	52.2
Overhead expenses	81.8	23.7	105.5
Financial Costs / Bal. Exchange Rate	11.5	14.4	25.9
ITBMS	47.1	25.6	72.7
Acc (+) / Def (-) Costs	-12.0	0.6	-11.4
Total Costs	1,878.4	1,175.5	3,053.9
Economical balance	-682.8	-327.9	-1,010.7
	(audited by IG/ACP)		

Health & Safety Statistics - GUPC and its Subcontractors	Actual	Standard (*)
Average quantity of workers		
. Female	215	
. Male	5,001	
. Total	5,216	
Worked days	1,418	
Worked hours	64,987,880	
Working Accidents		
. Fatalities	5	5
. Cases w/ lost days	892	
. Cases w/ Job restrictions	0	
. Other recordable cases	73	
. Total accidents	970	
Lost working days	7,316	
Incident Rate *(qty. accid. / qty. hr) * 200000*	2.99	3.80
DART *(qty. cases lost days / qty. hr) * 200000*	2.76	2.30
Duration Rate *(lost days / each accid.)*	7.54	

Pacific Site Batch Plant, Crusher Plant, Rebar Fab Shop and laydown areas

Electromechanical Fabrication and Installation Progress - As of November 2013					
E&M Activities	Prep. works	Fabrication	Install.	Commis.	Total
Valves, Bulkheads & Trashracks	99.2%	98.4%	6.7%	0.0%	80.8%
Gates and Assoc. Mechanisms	98.9%	74.8%	0.3%	0.0%	68.3%
Mechanical Systems	80.9%	46.0%	0.1%	0.0%	58.0%
Electrical Systems	93.6%	51.2%	2.4%	0.0%	41.6%
Controls	80.2%	41.3%	0.0%	0.0%	34.0%
Others	61.7%	27.3%	53.0%	27.3%	42.5%
Totals	98.3%	72.1%	3.0%	0.5%	60.0%

Gates roll into place

First Gate travelling down a special made highway to the locks

First Gate moves into the lock chamber on the Atlantic side.

ATLANTIC – GENERAL – WSB AND CHAMBERS

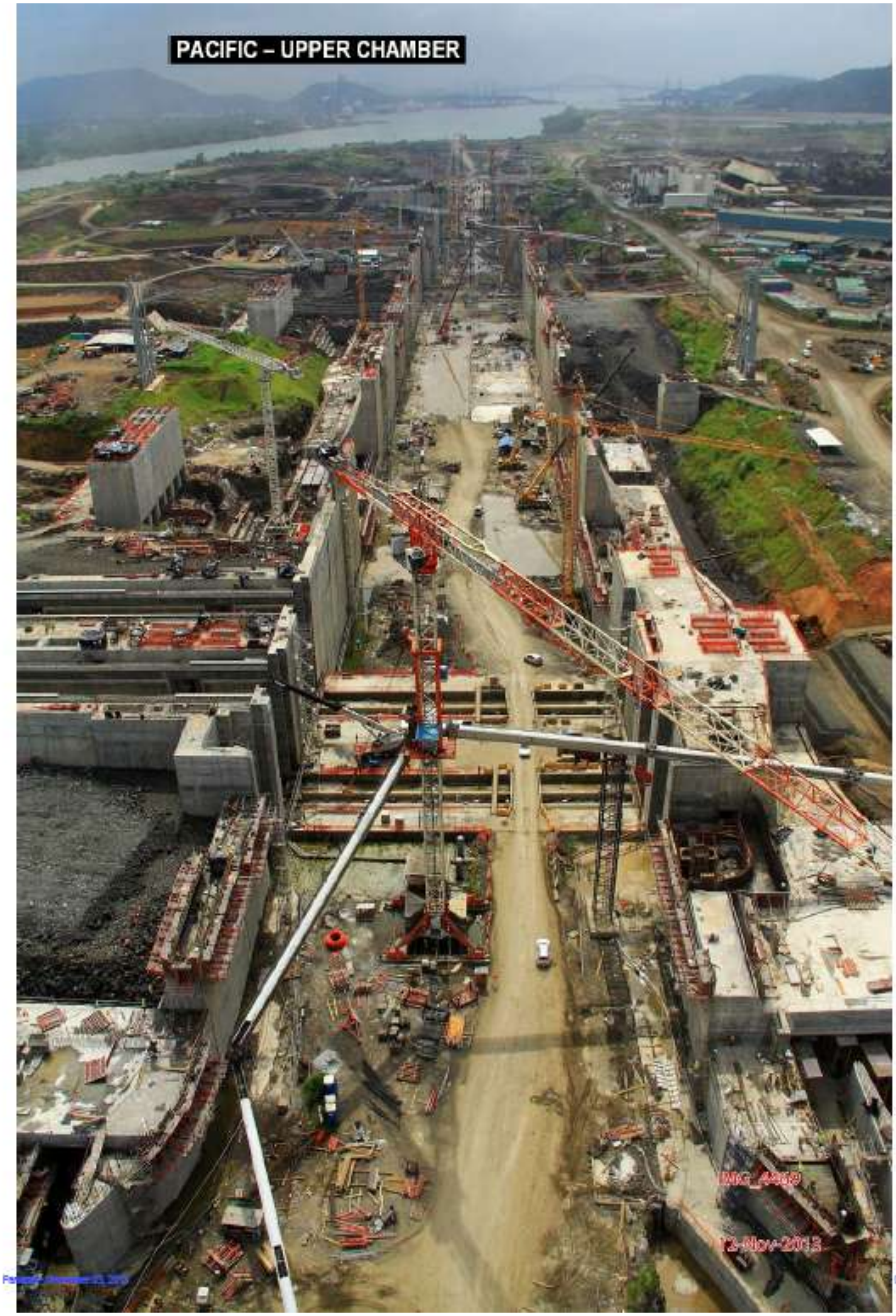
ATLANTIC – LHI & WING WALL

ATLANTIC – LH1 & BACKFILLING

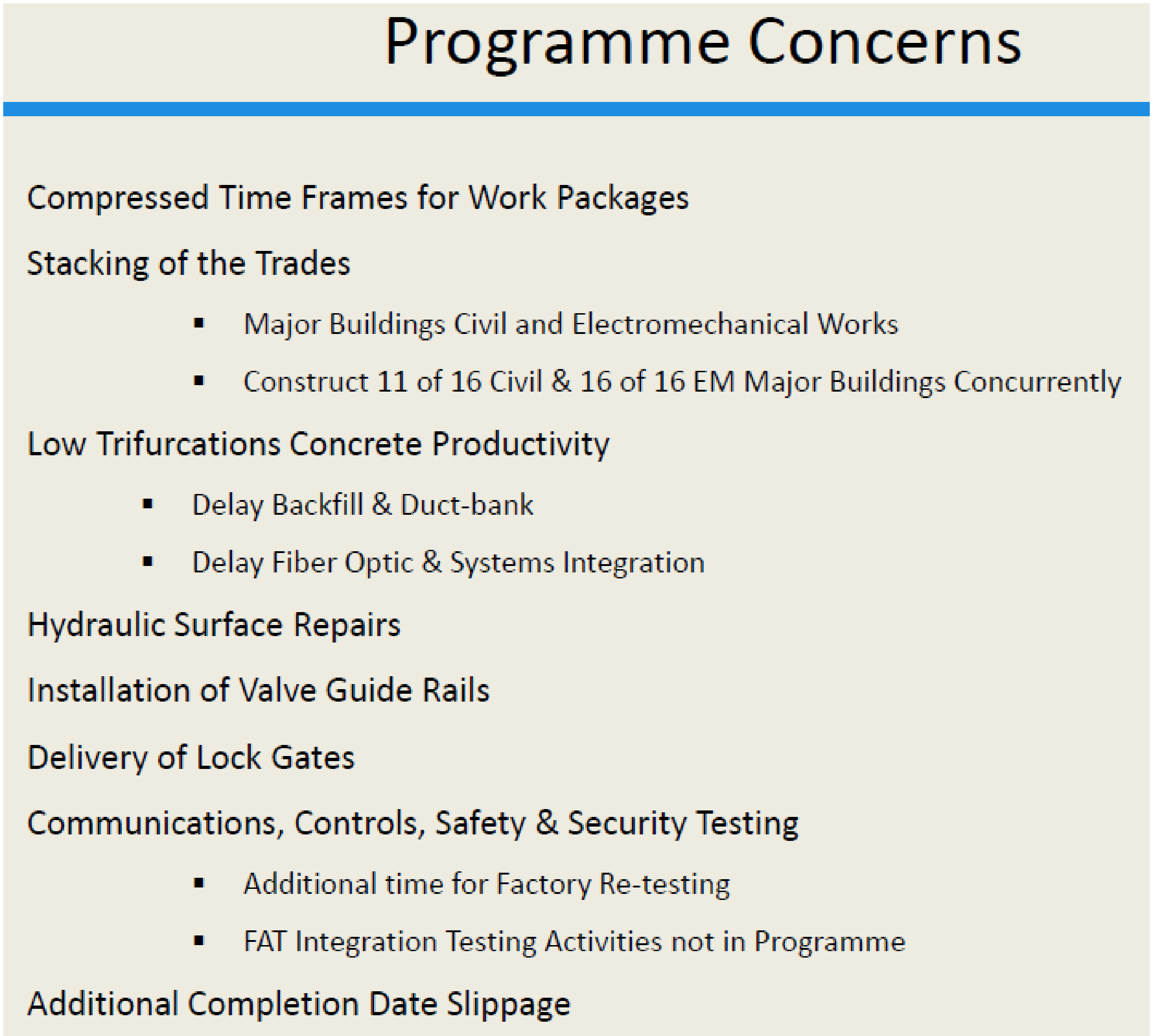
ATLANTIC – VALVE STRUCTURE 2


IMG_4353
12-Nov-2013
PACIFIC – LH1 & BACKFILLING


IMG_4120
12-Nov-2013
PACIFIC – LH1 & BACKFILLING


PACIFIC – UPPER CHAMBER

Problems and Issues




Concrete Quality – Atlantic Site
Atlantic Site
Voids and Honeycombs in Valve Structures,
Backfill and WSB Conduits
December 4, 2013


Concrete Quality – Atlantic Site
20131126
LMC Conduit
Atlantic Site,
Pending Seepage Repairs
December 4, 2013


Concrete Quality – Pacific Site
CC5-J-04
Pacific Site
Cold Joint Defects, Voids and Overhead Repairs
December 4, 2013


E/M Quality – Pacific Site
H2E-3C
Pacific Site
Fender Steel Templates Alignment

Summary of Concerns

- Contractor's financial ability to perform and complete: cash flow; repayment of advances/deferrals
- Schedule uncertainty and changed completion dates
- Work Force levels
- Six Months targets (May, 2014)
  1. Concrete work
  2. Delivery of gates
  3. Valves
  4. Machinery Room Buildings
  5. Dam Fillings
- Electrical and Mechanical Schedules
- Instrumentation and Control Systems Schedules
- Testing and Commissioning preparation
- Safety

December 4, 2013

General Claims Statistics

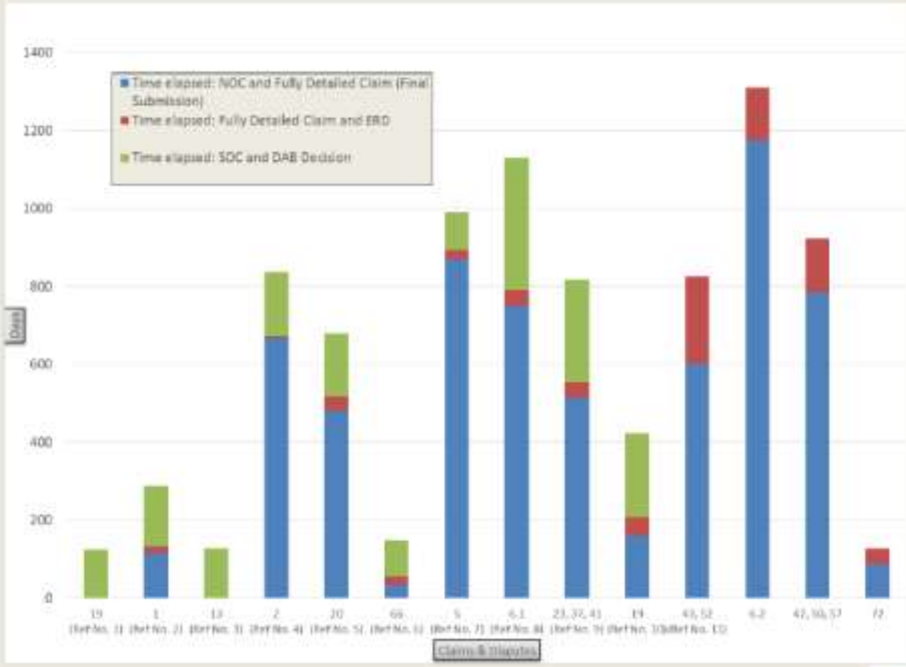
- A total of **89** notices of claims have been submitted through Nov. 2013
- Only 10 fully detailed claims have been presented to the Employer
- 60 notices of claims are pending to be substantiated
- Employer's determinations have been issued for **20** claims
- **13** claims have been referred to the DAB
- Resolution is complete for **11** claims [1 DAB Decision, 1 combined with another claim and 9 cancelled]

CANAL DE PANAMÁ

Claims Submitted by GUPC

Subject	Related Claims	GUPC CLAIM AMOUNT	RELIEF GRANTED BY ERD OR DAB DECISION
Mangrove Compensation	01	455,800.00	-
Dewatering of the Pacific 1939 Excavations (Invasive Crabs)	02	478,357.93	177,259.00
Range Target No. 2 (Protection Works)	05	171,899.00	44,435.00
Pacific Entrance Cofferdam and Dredging	6.1	120,082,092.00	-
Differing Physical Conditions - Pacific Site	6.2	35,180,619.00	-
Change in Legislation - Law 8 of March 15th, 2010	10	18,405,603.61	10,915,864.23
Change in Legislation - Law 49 of Sept 17th, 2009	11	467,977.43	-
On-Site Testing Laboratories	19	18,047,472.13	14,822,970.54
Mud in 1939 Excavation	20	7,310,942.69	2,879,668.72
Exceptionally Adverse Climatic Conditions – Atlantic Site	23, 37, 41	9,838,687.00	-
Under-certification for Interim Payment (Aug 2010)	26 - 33	293,555.84	-
Continuing Under-certification of Interim Payment (Oct 2010)	39	2,818,777.33	-
Delay and Disruption to Concrete Aggregate Production and Concrete Mix Design	43, 52	497,529,840.00	-
Adverse Physical Conditions at and below the foundation level of the LUC – Pacific Site	47, 50, 57	55,944,465.00	-
Fire Fighting Control System	72	1,280,639.17	-
Cumulative Impact Claim	79	880,000,000.00	-
TOTAL		**1,648,306,728.13**	**28,840,197.49**

Time Period for Claims Resolution



CANAL DE PANAMÁ

Contractor's Allegations ACP has "substantially failed to perform its obligations"

- Employer withheld key information regarding physical conditions
- PAC 4 status withheld
- Failed to restore the financial equilibrium
- Disrupted the DAB process
- Failed to certify payment in accordance with SC 14.6
- Failed to administer the Contract (design micro-managed)

CANAL DE PANAMÁ

Contractor's Current Position (in correspondence)

- Arbitration in Miami
- Infringement of bilateral investment treaties
- Risk of "huge delays"
- Overall settlement by December 31, 2013
- Talks of a 'complete collapse of activities on site'; and
- 'significant consequences in Panama'
- Further action unavoidable

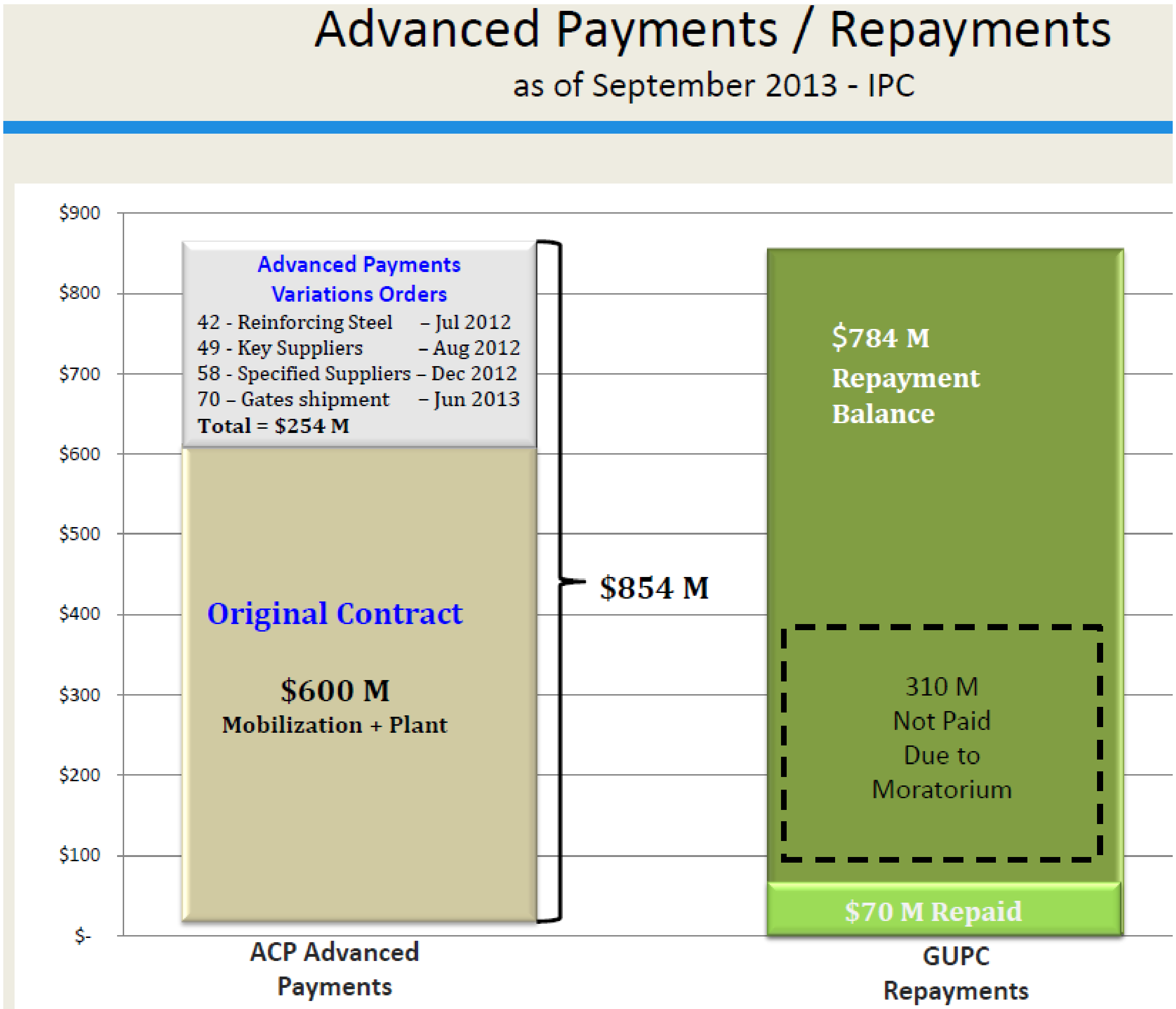
CANAL DE PANAMÁ

ACP Position

- Contractor's claims must be expeditiously determined by the DAB
- Any action by the Contractor on such grounds obviously invalid and deliberate default
- Referral 11 should be decided in January as planned
- Other disputes, 47/50/57 and 6.2 to be decided early in 2013

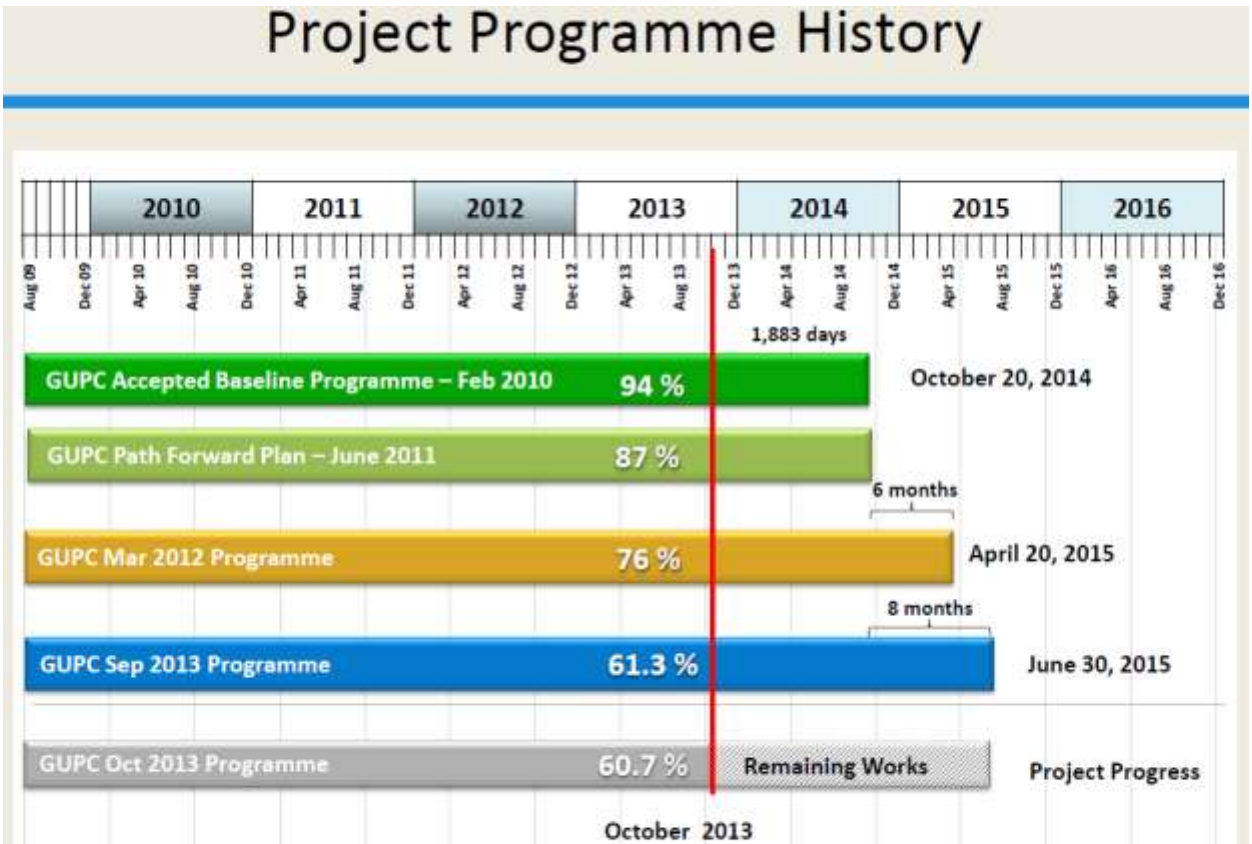
CANAL DE PANAMÁ

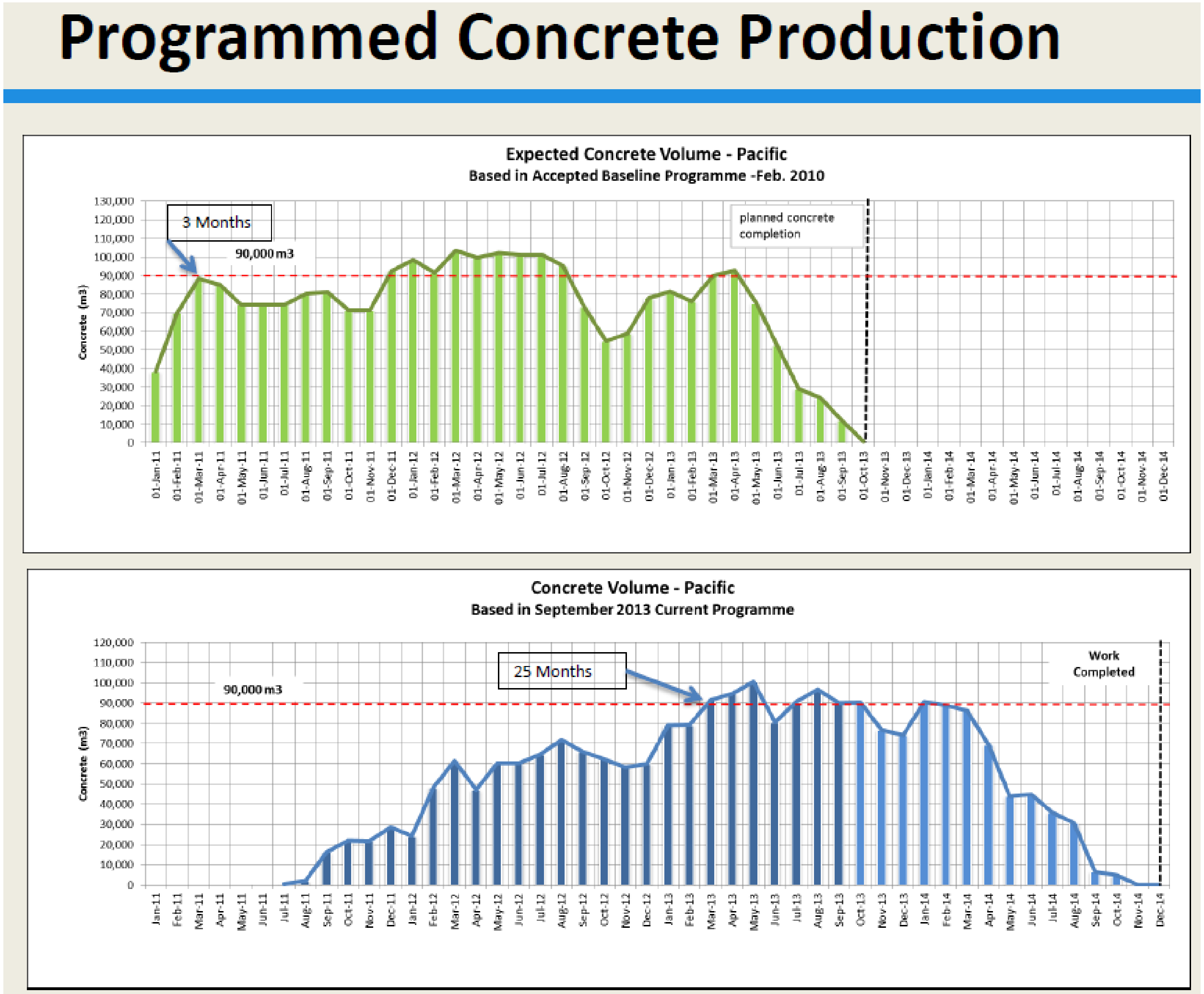
Current Progress and Projected Completion



Advance Payments				
Type	**Amount**	**Repayments**	**Remaining**	**Percent Remaining**
Mobilization	$300,000,000.00	$52,041,180.59	$247,958,819.41	83%
First for Plant	$100,000,000.00	$0.00	$100,000,000.00	100%
Second for Plant	$200,000,000.00	$0.00	$200,000,000.00	100%
Steel Price Adj.	$19,631,505.14	$18,669,453.91	$962,051.23	5%
Key Suppliers	$68,279,504.67	$0.00	$68,279,504.67	100%
Specified Suppliers	$147,415,983.94	$0.00	$147,415,983.94	100%
Gates	$19,131,685.60	$0.00	$19,131,685.60	100%
Total	**$854,458,679.35**	**$70,710,634.50**	**$783,748,044.85**	**92%**

Table 10-2 Advance Payments & Repayments





Contractual Issues

During the 4th quarter of 2013 there was continuous communication between GUPC and ACP concerning outstanding issues related to contractor claims and claimed outstanding payments. The contractor has claimed an additional $1.6 billion is owed to them. This culminated in the contractor proposing to suspend the works by notice on December 31st 2013 and ACP advising that this course of action was a breach of the conditions of contract.

Notwithstanding continuous dialogue and further written communication during January 2014 between the parties it is a matter of record that on February 5th 2014 all construction works were suspended by the contractor on both the Atlantic and Pacific sites. This period of suspension lasted at least 2 weeks. The parties commemorated an agreement through a Memorandum of Understanding (MOU) that was executed in March and signed in August 2014. The MOU included the following provision:

- The contractor finishes the works in December 2015.
- The contractor will deliver in Panama the 12 lock gates currently in Italy by February 2015. The gates are to be transported in staggered shipments.
- GUPC will pay US$100 million and ACP will advance US$100 million (guaranteed), which will enable works to regain a normal pace.
- The Performance Bond for US$400 million may only be released to Zurich North America, for the contractor to obtain financing for the same amount to complete the work.
- The moratorium for the repayment of advances may be extended until 2018, subject to fulfillment of certain milestones and other conditions.

Project Status Statement from GUPC

Impregilo-Widening of the Panama Canal

In relation to this contract, it should be noted that, during the first stage of full-scale production, certain critical issues were encountered that, due to their specific characteristics and the importance of the works to which they related, made it necessary to revise downwards the estimates on which the early phases of the project had been based. The most critical issues relate to, inter alia, the geological characteristics of the excavation areas with respect to the raw materials necessary to produce the concrete and the processing of such raw materials during normal production activities. Additional problems were discovered as a result of the adoption by the client of operating and management procedures differing materially from those contractually agreed, with particular reference to the approval procedures for the technical and design solutions proposed by the contractor. These situations, already specifically addressed in previous financial reports drawn up by the Group, have been further protracted in 2013. In view of the persistent unwillingness of the client to reasonably implement the appropriate tools contractually provided for the management of these disputes, the Group has acknowledged the consequent impossibility of the contractor – and therefore of the original contracting partners – to continue, at their own entire and exclusive risk, the construction activities required for completion of the project, with full assumption of the financial burden required for this purpose, without any concrete guarantee of specifying a mutually agreed objective with their counterparts. Against this background, therefore, at the end of 2013 the Group stated its formal intention to suspend work immediately if the client once again demonstrated its unwillingness to deal with the dispute in accordance with a contractual approach characterized by good faith and the mutual willingness of all parties to come to a reasonable agreement. Meetings between the parties, assisted by their respective legal and contract advisers and experts lasted throughout February 2014 and on 13 March 2014 a memorandum of agreement was signed. The essential elements of the agreement provide, in return for the undertaking of the contractor to resume work and finish it by 31 December 2015, a commitment by the client and the contracting companies to providing funding for the outstanding works up to a maximum of $US 1.4 billion. This commitment will be met by the client through (i) suspension of the return of contractual advances already paid of approximately $US 800 million and (ii) the provision of additional advances of $US 100 million, while the Group of contracting companies will contribute through (i) the direct provision of their own financial resources of $US 100 million and (ii) the provision of additional financial resources, through the conversion into cash of existing contractual guarantees, totaling $US 400 million. Repayment of the amounts allocated for the financing of the works to be carried out has been delayed in order to coincide with the pending outcome of arbitration proceedings, initiated contemporaneously, which will set out the liabilities of the parties in relation to all the extra costs incurred or remaining to be incurred as a result of the situation described.

In this context, it should be remembered that in previous years, the Impregilo Group had already applied an approach to the project which was reasonably prudence-oriented and clearly supported by its legal advisers, on the basis of which it had already provided for significant final losses, at that time only partially limited by the corresponding recording of additional fees claimed from the client and based on the expectation that their payment might be considered reasonably certain. Bearing in mind that since the end of the previous year the general critical situation, far from being resolved, had become further protracted as described below, it was decided, pending finalization of the abovementioned agreements, to update the overall economic forecasts for the whole life of the contract. In accordance and continuity with the assumptions previously made, in the face of a further increase in expected final costs, it was decided to update the valuation of the series of additional payments regarded as contractually payable and reasonably certain to be made, although deferred over time in accordance with the deadlines fixed in the agreement with the client. This activity has generated additional net residual costs which, in view of provisions made in previous years, have not assumed significant values in either absolute or relative terms and have been fully reflected in the income statement for 2013.

Sacyr-Claim Status

Grupo Unidos por el Canal, S.A. (GUPC) is a consortium of international companies charged with the design and construction of a third set of floodgates for the Panama Canal. The Sacyr Group proportionately consolidates its 48% investment in GUPC, since it is a jointly controlled entity in line with IAS 31.

The Group recognized the result on its holding in GUPC based on the Group's accounting principles, which consist in the recognition of income based on the percentage of completion of the work, taking into account the claims filed by the Company, and the degree of certainty assessed by it and by an independent expert.

At 31 December 2013, GUPC had received construction certificates amounting to 2,048 million US dollars, which represents a 66% percentage of completion of the work, recognized and paid by the Client. Also, at 2013 year-end, the balance of advances made by the ACP to GUPC amounted to 784 million US dollars, which relate to advances stipulated in the agreement ("Mobilization Security" amounting to 248 million US dollars and "Plant Security" amounting to 300 million US dollars); and the remainder (236 million US dollars) to a series of modifications signed with the ACP, for adjustments relating to the price of steel, key suppliers and specific suppliers.

GUPC filed various claims, objectives and quantified amounts totaling 1,625 million US dollars. These claims arising from various unforeseen costs arising in the project are in a settlement phase in line with that stipulated in the contract between the company and the Autoridad del Canal de Panamá (ACP). This contract establishes a system to resolve claims or disputes based on three resolution levels:

1) the claims must be notified to the ACP, which may recognize all or a part thereof;

2) the claims rejected by the ACP should be addressed to the DAB (Dispute Adjudication Board), formed by three experts, one chosen by the ACP, another by GUPC and a third expert who is appointed by mutual agreement between both;

3) lastly, the claims may be addressed to the ICC's Arbitration Court with headquarters in Miami, subject to Panamanian Law, governed by the regulations of the International Chamber of Commerce). The arbitration proceedings established will take a decision on the liability of those unforeseen costs with respect to which the GUPC has presented various claims.

The main claims are as follows:

1.- Claim 6.1 Pacific Cofferdam, amounting to 120 million US dollars. This claim is pending resolution by the ICC.

2.- Claim 43 on the suitability of basalt, amounting to 497 million US dollars.

This claim is pending resolution by the DAB.

3.- Claim 78 Disruption, amounting to 880 million US dollars. This claim is pending resolution by the ACP.

Likewise, as indicated in the note relating to "Events after the balance-sheet date", in March 2014, GUPC and ACP entered into an agreement which sets the completion date on the works for December 2015. At the date of authorization for issue of these consolidated financial statements, the construction works on a third set of floodgates for the Panama Canal are being executed within the new periods established, accordingly, GUPC has not considered any relief for the advance of the delivery of the works, nor any penalties for delays in the completion of such works.

Sacyr

Consolidated income statement

STATEMENT OF INCOME (Thousands of Euros)	DECEMBER		% chg
	2013	2012	13/12
Turnover	3.065.026	3.423.873	-10,5%
Other Sales	186.309	204.143	-8,7%
Total Income	3.251.335	3.628.016	-10,4%
External and Operating Expenses	-2.875.861	-3.042.200	-5,5%
GROSS OPERATING PROFIT	375.474	585.816	-35,9%
Depreciation	-186.961	-185.274	0,9%
Trade Provisions	-98.409	-369.905	-73,4%
NET OPERATING PROFIT	90.104	30.637	194,1%
Financial results	-341.061	-363.075	-6,1%
Forex results	-9.904	479	n.s.
Results from equity accounted subsidiaries	160.137	-869.090	-118,4%
Provisions for financial investments	-46.270	-36.336	27,3%
Change in value of financial instruments	-7.812	-9.661	-19,1%
Results from sales of non current assets	27.864	37	n.s.
PROFIT BEFORE TAXES	-126.942	-1.247.011	89,8%
Corporate Tax	-194.967	347.834	n.s.
PROFIT FOR CONTINUING ACTIVITIES	-321.909	-899.177	64,2%
RESULTS FOR COMPANIES WITH DISCONTINUOS ACTIVITIES	-188.874	-77.575	-143,5%
CONSOLIDATE RESULTS	-510.783	-976.752	-47,7%
Minorities	14.852	-784	n.s.
NET ATTRIBUTABLE PROFIT	-495.931	-977.536	49,3%

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REFERENCES

1. Wikipedia.com
2. ACP (Panama Canal Authority). 2001. "History of the Panama Canal: French and American Construction Efforts." http://www.pancanal.com/eng/history/history/index.html.
3. United States Department of Agriculture, 2010. "Impact of Panama Canal Expansion on the U.S. Intermodal System." http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5082003
4. GUPC Feb 2014 Progress Report.
5. Canal De Panama, Panama Canal Expansion Program, various dates and reports, http://www.pancanal.com/eng/expansion/
6. Panama Canal Photos, http://interactive.wxxi.org/highlights/2011/01/panama-canal-american-experience
7. "Panama Canal History", http://news.nationalgeographic.com/news/2013/08/130816-pictures-panama-canal-
8. "Unlocking Panama's Potential, Dec. 2009, http://www.ingenia.org.uk/ingenia/articles.aspx?index=577
9. "Panama Canal Expansion", August 21, 2011, http://www.oil-electric.com/2011/08/panama-canal-expansion.html
10. "Panama Canal Third Locks 1939-1942", http://www.globalsecurity.org/military/facility/panama-canal-third-locks.htm
11. Panama Canal Facts, "Facts", Mar 27, 2010, http://panamacanalfacts.com/
12. Grupo UPC, Latest News, Various articles, http://www.gupc.com.pa/
13. Sacyr Annual Report 2013, http://informesanuales.sacyr.com/en/
14. Salini Impregilo Annual Report 2013, http://www.salini-impregilo.com/static/upload/imp/impregilo-annual-20131231/impregilo-annual-20131231.pdf