# Development of the SP-SSA International Terminal, Vietnam

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## ABSTRACT

Located on the Cai Mep River in southern Vietnam near Vung Tau, approximately 85 kilometers (53 miles) from Ho Chi Minh City and 25 kilometers (15.5 miles) from the South China Sea, the new SP-SSA International Terminal (SSIT) will be able to handle 1.5 million 20-foot equivalent units at buildout. In 2006, Vietnam was the fastest-growing economy in Southeast Asia at 7.8 percent for the year, and SSIT is being developed to ensure that Vietnam's port infrastructure is adequate to sustain this growth.

Master planning and bringing this modern container terminal online presented great challenges. The terminal's 60-hectare (148-acre) site was an intertidal salt marsh covered with date palm, and geotechnical testing showed that the upper 45 meters (150 feet) of soils were poorly consolidated clays and would require substantial ground improvement.

The first stage of construction reclaimed the site with approximately 3.5 million cubic meters (4.6 million cubic yards) of sand and 6.6 million meters (4,100 miles) of wick drains. Dredging and slope revetment constituted the second stage of construction. The project also constructed the marine works, consisting of a pile-supported quay capable of supporting multiple tandem-lift super post-Panamax ship-to-shore gantry cranes and a pile-supported barge quay dedicated to supporting the barge traffic that prevails in Vietnam. The final stage of construction involves paving, utilities, and miscellaneous support buildings. Based on its current progress, the project will be complete and the terminal will be operational by January 2012.

This paper describes the background, planning, design, and construction challenges involved in creating and implementing a master plan for a modern container terminal over a soft-soiled environment.

## INTRODUCTION

SP-SSA International Terminal (SSIT) is being developed to handle the goods being produced in Vietnam and spread throughout the world's economy. SSIT is a joint venture company between Saigon Ports and SSA International Holdings, Inc. SSIT is located 85 kilometers (53 miles) south of Ho Chi Minh City in the Ba Ria-Vung Tau Province, approximately 8 kilometers (5 miles) north of the South China Sea (Figure 1).

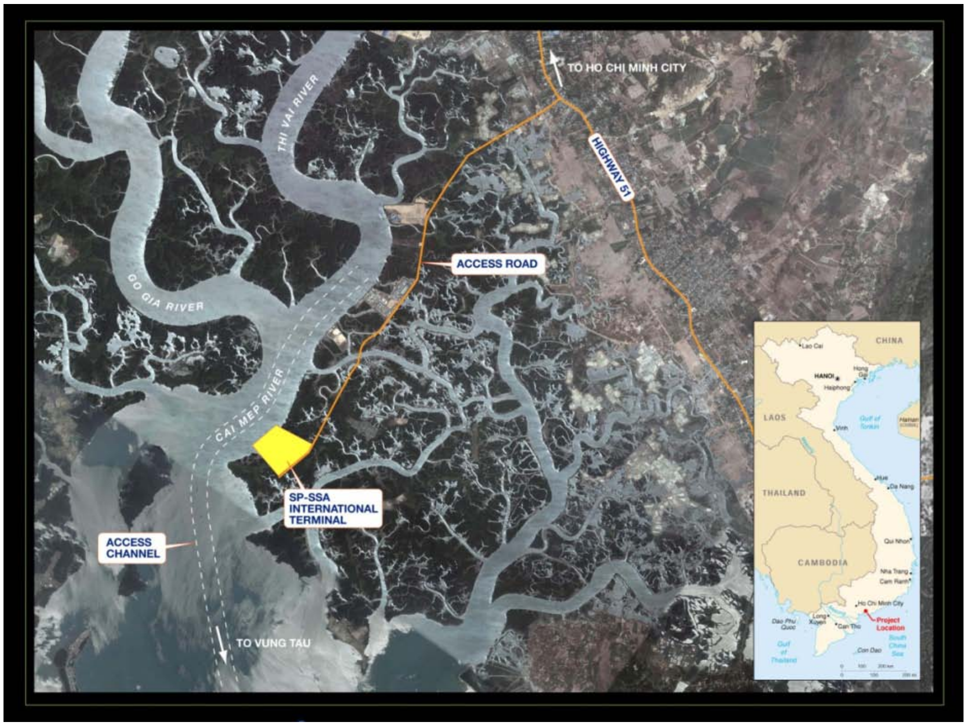


**Figure 1. Vicinity map.**

The SSIT concession consists of approximately 60 hectares (150 acres) of intertidal salt marsh. The soils, which are mainly alluvial and carried by the region's river systems, are composed primarily of loose clay particles and range from 40 to 50 meters (130 to 160 feet) in thickness. The underlying stratum generally consists of weathered granite and dense sands. The waters immediately adjacent to the concession are more than 18 meters (60 feet) deep. With its naturally deep waters and imposing geotechnical conditions, this project is enormously challenging.

This paper describes the background, planning, design, and construction challenges associated with creating and implementing a master plan for a modern container terminal over a soft-soiled environment.

## BACKGROUND

In October 1999, the Vietnamese government approved a master plan that would develop the nation's port system in eight groups. Its chief objectives were to modernize the ports' existing infrastructure and develop deep-water seaports that could accommodate vessels in excess of 30,000 dead weight tons.

The government had set a long-term goal of implementing the maritime sector by 2020. One of the key regions of the plan was the south key economic zone, and for that zone, the thrust of the plan was to relocate existing terminals from the shallow waters near Ho Chi Minh City to the deep waters near Ba Ria-Vung Tau Province. In 2005, the container throughput of Ho Chi Minh City was 2.1 million 20-foot equivalent units (TEUs) and the region anticipates growth of 8 to 10 percent per annum after year 2012.

## MASTER PLAN

Early on in the master planning effort, the project proponents decided to incorporate two key operational requirements. Because the world is becoming increasingly aware of environmental conditions and because the price of diesel fuel is uncertain, the first requirement was that most of the container handling equipment was to be electric. Vietnam has a wide network of navigable rivers, so the proponents also required that the waterside container operations be able to transport containers to and from barges as well as ships. Barge traffic is considered the most efficient and cost-effective solution for the transport of containers within Vietnam, and being able to handle barges was necessary to the terminal's success.

Tide ranges along the Cai Mep River are in excess of 3 meters (10 feet). The existing nominal groundline elevation within the site was approximately +3 meters (+10 feet) Chart Datum Level (CDL), while the mean sea level was about +2.67 meters (8.76 feet) CDL. For the terminal to be above the normal tide ranges, it would have to be elevated to a nominal +6 meters (+20.0 feet) CDL, which would entail a substantial reclamation process.

## OVERVIEW

Figure 2 shows a rendering of the completed terminal. The ultimate annual container throughput capacity of the terminal is estimated to be 1.2 million TEUs. The annual contribution of the barge quay is estimated to be 300,000 TEUs.

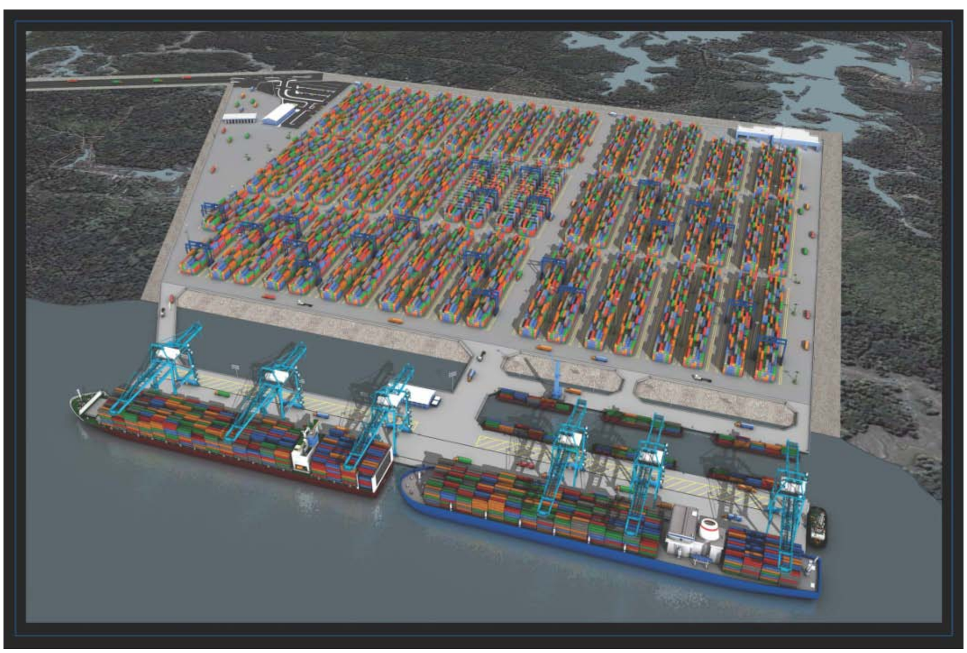

**Figure 2. Artist's rendering.**

Table 1 depicts the various infrastructure improvements that are to be incorporated into the final master plan.

**Table 1. SSIT Project Aspects**

| Description | Size |
|---|---|
| Quay | 60 x 601.25 m |
| Berthing Depth | Dredge elevation: -14.5 m (CDL) |
| Trestle | 4 – 13 x 40 m |
| Barge Quay | 22 x 290 m |
| Barge Slip | 58 x 290 m<br>Dredge elevation: -4.0 m (CDL) |
| Tug/Pilot Area | 60 m |
| Secured Terminal Area | 50 ha |

## DEVELOPMENT

The project was divided into a series of construction contracts. The intent of the multiple construction package approach was two-fold: to encourage the use of Vietnamese contractors to the maximum extent possible, and to shorten and control the schedule of the project.

The preliminary schedule was approximately 3 years from the start of the reclamation process to the start of container movement. The estimated cost of the project, including equipment, was approximately $300 million. The marine aspect, which included the quay and barge quay, occupied approximately 10 hectares (25 acres) while the upland container yard, which includes the slope revetment, occupies the remaining 50 hectares (124 acres).

Construction was broken into contract packages that were manageable from the standpoints of physical effort and financing. The four packages included clearing, grubbing, and reclamation; dredging; quay, and barge quay development; and container yard and support building development.

## LAND RECLAMATION

The existing site is dominated by 45 meters (150 feet) of poorly consolidated alluvial soils. In order to determine the magnitude of the settlements across the site, two variables needed to be considered. The first was the addition of 3 meters (10 feet) of reclaimed sand acting as a constant dead load having a unit weight of 1.8 tonnes per cubic meter, and the second was the cyclic uniform live load of stacking containers six high throughout the container yard. Based on the loading requirements from the reclaimed sand, the uniform live load, and the geotechnical properties encountered during the soils investigation, it was believed that approximately 2.5 to 3 meters (8 to 10 feet) of settlement would occur throughout the site over the 50-year period of the concession.

Various parametric studies were performed during the design process. They included evaluations (from the analytical as well as the financial perspectives) of solutions, such as deep soil mixing, stone columns, soil replacement and surcharge with wick drains. The studies concluded that introducing surcharge and wick drains would be the most effective means of inducing a global settlement across this very large area.

Even with an aggressive surcharge and wick drain consolidation program, it was estimated that approximately 3 years would be required to remove all of the potential settlement. To meet the schedule, it was decided to allow a post-construction settlement of 20 centimeters (8 inches) over a 20-year period. While the operators feared this settlement would disrupt container operations, the team concluded that this amount over 20 years would be manageable.

The detailed design of the land reclamation package concluded that approximately 2.4 meters (8 feet) of settlement would occur over the course of the 2-year consolidation program. Based on the bathymetric and site surveys conducted during detailed design, it was estimated that approximately 3.5 million cubic meters (4.6 million cubic yards) of sand would need to be placed within the boundaries of the container yard. Figure 3 illustrates the typical section used for the consolidation program.

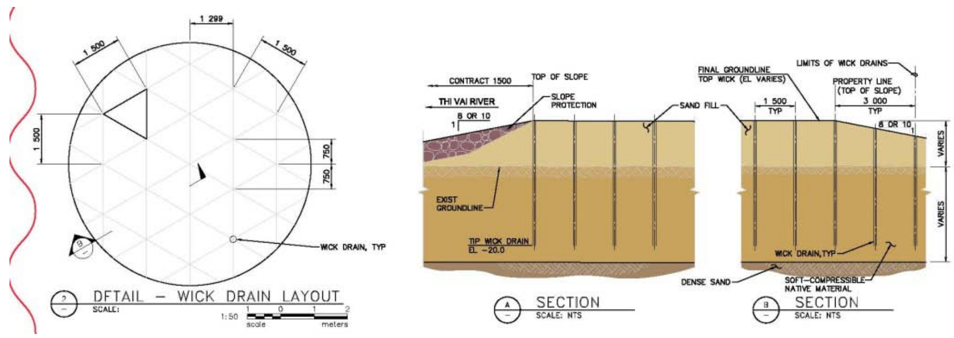


**Figure 3. Land reclamation typical section.**

In May 2008, the land reclamation process of the site was started. The package called for the import of 3.5 million cubic meters (4.6 million cubic yards) of reclaimed sand, as well as the installation of 265,000 wick drains that would measure more than 6.6 million meters or 4,100 miles laid end to end.

The Vietnamese contractor who won the tender mined sand from the Mekong Delta and transported it approximately 180 kilometers (112 miles) to the project site. A typical barge in Vietnam can carry upwards of 1,000 cubic meters (1,307 cubic yards) of sand per transit, which would amount to about 3,500 round trips by barge, so logistics were sure to be a concern.

Pump stations positioned along the front edge of the site pumped the sand to the site hydraulically. Typically, 20,000 cubic meters (26,000 cubic yards) of sand were placed per day. The record for a single day's placement came in early September 2008, when more than 52 barges and over 50,000 cubic meters (65,400 cubic yards) of sand were pumped and placed. Photo 1 shows the method of placement of the sand and the effort it took to obtain the specified compaction. By June 2009, 10 months later, 3.5 million cubic meters (4.6 million cubic yards) of sand and over 6.6 million meters (4,100 miles) of wick drains had been placed. Early on, settlement had been dispersed evenly throughout the area. As of August 2009, the average total settlement across the site is approximately 1.6 meters (5.3 feet), which is consistent with the estimated total settlement of 2.4 meters (7.9 feet).

**Photo 1. Aerial overview, November 2008.**

## SLOPED REVETMENT

In March 2009, the slope revetment for the terminal was started. The slope revetment acts as counter weight along the front edge of the terminal and has a slope of 8 horizontal to 1 vertical. The revetment is approximately 2 meters (6 feet) in thickness and is comprised of blanket stone with a nominal 5 cm (2 inch) thickness and armor stone with a nominal 40 cm (16 inch) thickness (see Photo 2). It is estimated that the slope revetment will be completed by November 2009.

**Photo 2. Sloped revetment, June 2009.**

## QUAY

The existing underwater slopes in the region are flat because of the poor soil conditions and are mostly 8 horizontal to 1 vertical or flatter. To take full advantage of the deep water near the concession's northern border, the quay would need to be set off from the container yard.

The 600-meter (2,000-foot) northern border of the waterfront could support two Panamax berth positions. Operational requirements along the quay called for the use of single-hoist, tandem-lift ship-to-shore (STS) gantry cranes. The STS gantry crane gage was set at 30.48 meters (100.0 feet) and the rated load under the spreader was specified at 80 tonnes (T). The outreach from the waterside rail was set at 65 meters (215 feet), meaning that the cranes would be able to service post-Panamax container vessels that are 22 containers wide. For circulation purposes, the quay was to have a service aisle waterside of the waterside crane rail and the hatch cover laydown area, with circulation lanes behind the landside crane rail.

The preliminary and detailed design phases of the project evaluated various structural alternatives for the quay, but because of the thickness of the consolidated alluvial soil, most were eliminated quickly and design focused on a pile supported quay.

The quay is home to buildings that supply fire suppression, water, fiber optic, and other utilities, and a two-story crane maintenance and longshore building is located midway along the quay. The final marine surface features plan of the terminal is shown in Figure 4.

The final quay configuration is a pile-supported structure that measures 60 meters by 600 meters (200 feet by 2,000 feet) with two independent trestles that provide traffic circulation to and from the container yard. The quay's structural components are designed to handle tandem lift 22-wide STS (30.48-meter [100.0-foot] gage) gantry cranes. The quay has a 6-meter (20 foot) service aisle along its front edge, as well as a laydown area 15 meters (49 feet) wide for hatch covers, and two circulation lanes adjacent to the landside crane rail (Figure 5).

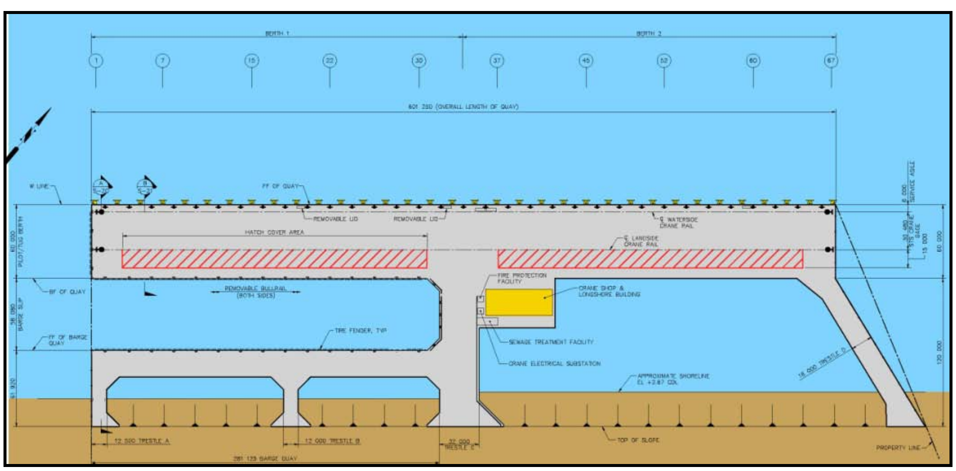


**Figure 4. Marine surface features.**

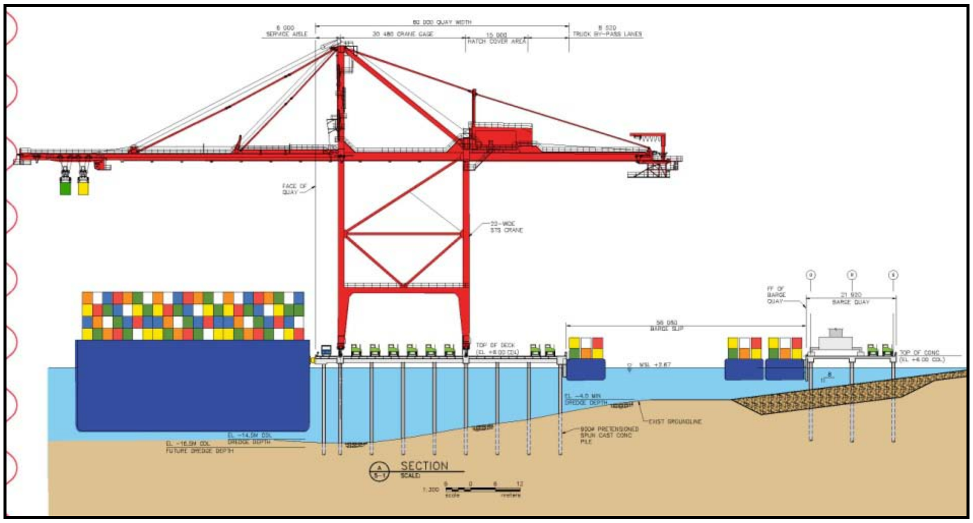


**Figure 5.  Marine typical section.**

Because of the large STS gantry cranes that will operate on the quay, the loads induced into the crane beams and pilings were on the order of 90 tonnes/meter during an operating condition.  Coupled with the large STS gantry crane load was the addition of a 3 tonnes/square meter uniform live load.  The terminal is located in an active typhoon zone, and the crane stowage loads were therefore on the order of 110 tonnes/meter.

The structural system for the pile-supported quay consists of 90-centimeter (approximately 3 foot) spun cast concrete pilings with transverse cast-in-place pile caps and longitudinal crane beams.  The superstructure for the quay consists of precast concrete deck panels topped with a cast-place concrete topping.

## BARGE QUAY

The limited berth space and the availability of a large container yard, coupled with the decision to use high production electrified rubber-tired gantry cranes (eRTGs), made the marine aspect and the container operations that would be close to it the focus of attention for the master plan.  A separate barge quay was identified as a means to increase the terminal's container throughput.  The barge quay would be operated by a series of small mobile harbor cranes working along it.

The barge quay is located approximately 58 meters (190 feet) landside of the quay. With the addition of a barge slip, barges can be positioned on the back face of the quay as well as on the front face of the barge quay.  Barge containers will be serviced along the slip by using an extended back reach on the STS gantry crane located along the quay or a small mobile crane located along the barge quay (Figure 6).

**Figure 6. Quay and barge quay rendering.**

The barge quay measures approximately 22 meters by 300 meters (72 feet by 1,000 feet) and is serviced by three circulation trestles that will transit containers to and from the container yard.

The structural loading of the barge quay consists of a uniform live load of 3 tonnes/square meter (600 pounds/square foot) and the structural components of the barge quay are similar to that of the quay. Bent spacing along both the quay and barge quay is set at 9-meter (30-foot) centers to take advantage of the large-diameter spun cast concrete piles. The pilings are estimated to be about 56 meters (180 feet) long; they will be cast in two segments, which will be butt-welded at the joint prior to driving.

## CONTAINER YARD

Using eRTGs was one of the operational requirements for the terminal. They were to be seven wide (7+1) and have the capacity to stack seven high (1 over 6). The eRTG stacks are positioned back-to-back so that they can be served by electrical cables fed from a single location (Figure 7).

A quay and barge quay detached from the container yard present circulation problems within the terminal. Traditionally, containers are parallel with the quay; because of the set position of the trestles, equipment is not able to transit to the quay at will. In order to accommodate the back-to-back stacking of the containers and the pre-positioned location of the trestles, the container rows were rotated 90 degrees to be perpendicular to the quay. In this particular terminal, the rotation made the drainage patterns predictable, with a series of peaks and valleys run in the same direction as the container stacking. Figure 8 depicts the final terminal layout.

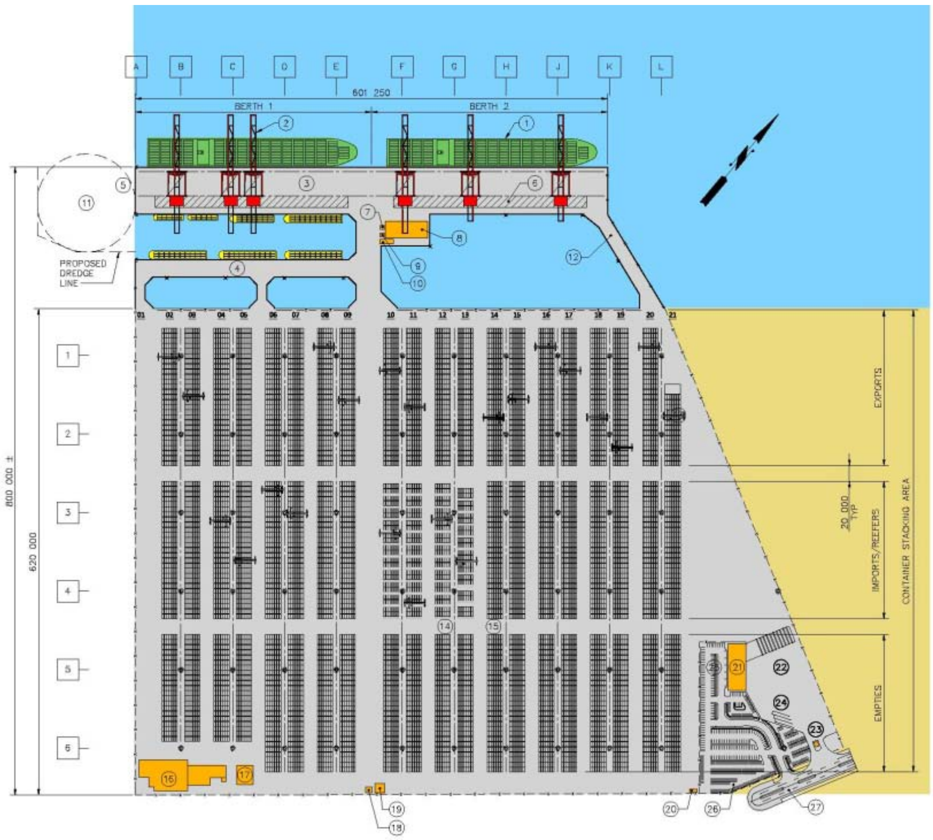


**Figure 7. Terminal layout.**

## SUMMARY

Implementation of the SSIT master plan involves the implementation of three construction contracts. The project included reclamation, dredging and slope revetment, the construction of a pile-supported quay capable of supporting multiple-tandem-lift super post-Panamax ship-to-shore gantry cranes and a pile-supported barge quay, and paving, utilities, and miscellaneous support buildings. Contract 1000, which consisted of sand reclamation and wick drains was started in May 2008 and was completed in July 2009 on time with the project schedule. Contract 2000, the marine works contract, is scheduled to start in September 2009. Contract 3000, the upland works and container yard, is scheduled to start in March 2010. Based on the current progress of construction at the site, the project will be complete and the terminal will be operational by January 2012.