

Norfolk International Terminals South Wharf Renovation

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TABLE OF CONTENTS

I. Project Description..... Page 2

II. Introduction – Project Highlights..... Page 2

III. Goals and Objectives/Business Problem..... Page 3

 Background..... Page 3

 Objectives and Methodology..... Page 3

 Hardware/Software Used.....Page 10

 Project Cost.....Page 10

 Performance Measures.....Page 11

 How the Project Fulfills the Award Criteria.....Page 12

IV. Conclusion..... Page 12

I. Project Description

In 2000, the Virginia Port Authority (VPA) undertook a large-scale renovation of the South Terminal at Norfolk International Terminals (NIT) adjacent to the Elizabeth River in Norfolk, Virginia. The first step in these renovations included the replacement of 4,230 linear feet of wharf with a new state-of-the-art wharf designed specifically to handle containerized cargo. The second step of the renovations includes the renovation of 150 acres of backlands to accommodate straddle carrier operations. The wharf replacement has been completed and the backlands reconstruction is underway. These improvements are part of the Virginia Port Authority 2040 Master Plan to accommodate a projected doubling of containerized cargo coming through The Port by the year 2020.

II. Introduction – Project Highlights

The following list includes the major highlights of the successful renovation of the NIT South Wharf:

- Demolition and reconstruction of 4,230 linear feet of wharf in 2-1/2 years
- No impacts to ship operations during reconstruction
- Innovative under-wharf detention basin to treat stormwater
- 60-ft available dredge depth
- Innovative approach to environmental mitigation project
- Cost control – only 5% contract increase due to change orders

III. Goals and Objectives/Business Problem

Background

NIT is the “flagship” of the VPA’s four terminal facilities. It is the primary container handling facility within the VPA and accounts for nearly half of The Port’s total container throughput. NIT consists of over 648 acres of land, has excellent deep water access and is situated close to major transportation routes. Although the largest and busiest container terminal among the VPA’s facilities, the majority of the infrastructure and container handling equipment at NIT was aged and becoming functionally obsolete.

Originally constructed in four separate phases over a 25 year span, the primary container berth at the NIT South wharf (Figure 1) was functionally obsolete and in some cases deteriorated to an unsafe condition. The original container berth was constructed in the late 1960s and the first 50-ft gage crane with a 13-wide outreach was still in operation. Although the most recent construction was completed in the 1980s and remained in good overall condition, the 50-ft gage crane width and load limits made even the most modern sections of the old wharf functionally obsolete. Due to these conditions, the VPA made the strategic decision to replace the wharf as the first step in the complete renovation of the NIT South Terminal.

Objectives and Methodology

The following seven objectives were identified as part of the early criteria for the design and construction of the new wharf:

- 1) Increase the width of the new **wharf structure** to accommodate 100-ft gage cranes
- 2) Accommodate **dredge depths** to 60-ft
- 3) Minimize and mitigate **environmental impacts**

- 4) **Re-use existing structures** where possible
- 5) Accommodate **stormwater run-off** with no impacts to container operations
- 6) Address **community concerns** about noise and pollution
- 7) Phase construction to maintain three operational berths at all times with **no impact to ship operations**

1. Wharf Structure: The primary goal of the renovation was to increase the width of the wharf to accommodate new 100-ft gage container cranes. The old structure supported 50-ft gage cranes and over 70% of the structure required complete replacement. In order to minimize impacts on the container operations, the decision was made to step the wharf out into the river in order to obtain the required width increase. This decision minimized potential impacts to yard operations and also allowed more flexibility in meeting the dredge depths described below. The face of the new wharf was placed approximately 66 feet waterward of the original structure.

Low Maintenance: In addition to the new size, the wharf was designed to minimize maintenance. The old wharf structure was located very near low water, such that pile caps were often submerged during high tide. Due to the need to tie the new structure into the existing container yard elevations, raising the wharf more than a just a few inches was not a practical alternative. Therefore, a flat plate concrete structure with pile capitals was selected as the structural system. This system allowed the design team to keep the structure out of the tide zone, thereby minimizing impacts from direct salt-water intrusion.

Constructability: The flat plate design allowed great flexibility in pile driving tolerances. Because the contractor was demolishing an existing wharf and building a new one in the same place, the design team anticipated that potential conflicts and obstructions could be

encountered when driving new piles. Complete removal of all of the old piles was not considered cost effective. Therefore, the decision was made to minimize pile extractions, and allow the contractor to cut-off the old piles at the mud-line. The new pile layout was configured around the existing pile layout in such a way as to miss the old piles as much as practically possible. During construction, the contractor was provided a tolerance of 2-ft in any direction that a pile could be moved. Larger tolerances were accommodated with the addition of additional reinforcing to the flat plate structure. These types of tolerances would not have been achievable with a conventional pile cap and beam type of structure.

2. Dredge Depth: The VPA required the new wharf to be capable of dredge depths of at least 55-ft with a preference to being able to accommodate 60-ft dredge depths in the future. These criteria were driven by the fact that the VPA recognized that the new structure would likely be in service for the next 50-years, or longer, and any future retrofits would be very costly. Therefore, the design team worked with the pile sizes and spacing to accommodate the ability to dredge to 60-ft with no increase in the construction cost. The VPA has currently dredged the berth to 50-ft to accommodate the current world container fleet. As ship sizes continue to increase, the VPA will be able to keep up with the growth with only the need to perform additional dredging.

3. Environmental Impacts: A crucial criteria for the VPA was to first minimize environmental impacts, then to fully compensate for any unavoidable impacts. The use of an open pile structure on the same alignment as the old structure minimized the need to fill any additional river bottom. The open pile structure also minimized impacts to the river and only created additional “shadowing” on the river bottom. In addition, to the small shadowing impacts, the under-wharf detention basin, described below, impounded a portion of the river. These impacts were

identified and a unique mitigation project was undertaken by the VPA to compensate for the impacts. The Plum Point Park Environmental Restoration project required an innovative approach to mitigation compensation in order to gain regulatory approval for the project. The Design Master Plan (Figure 11) proposed the creation and/or restoration of a variety of habitats: a 5-acre passive recreation area overlooking the Elizabeth River, a one-acre saltwater marsh, and 2 acres of open water marine habitat. The regulatory agencies were hesitant to accept the plan because it did not meet the traditional “one-to-one” mitigation compensation ratios outlined by the Virginia Department of Environmental Quality (VDEQ) or the U.S. Army Corps of Engineers (USACE). However, by promoting a “landscape” approach to mitigation compensation, the VPA was able to convince the agencies that the benefits of multifaceted mitigation, such as those planned at Plum Point, were equal to or greater than the benefits of preserving or creating only one habitat type.

The VPA, in partnership with the City of Norfolk and others, created a 5-acre park – Plum Point Park (Figure 12) – which included the following highlights:

- Preserved 5 acres of open space
- Cleaned-up 2 acres of river bottom (over 500 piles and over 500 tons of debris)
- Restored 1 acre of wetlands
- Installed erosion control measures
- Created a park with native species, a bike path, and interpretive signs creating an education experience for park patrons

4. Re-use Existing Structures: As much as possible the VPA desired to re-use the existing structures. Through detailed inspections, the design team determined that the advanced deterioration of the first three container berths made them unsuitable for incorporation into the

new structure. However, the fourth container berth, constructed in the 1980's, was able to be re-used and incorporated into the new structure. This saved the need to demolish over 1300 ft of existing wharf structure, and allowed the fourth and final phase of construction to be completed in a very short time.

Although, the first three sections of container berth were not able to be incorporated into the new structure, the VPA was able to recycle much of the concrete from the demolition of the old structure and re-use the concrete as subgrade material on other construction projects at NIT.

5. Stormwater Run-Off: Another environmental concern for the VPA was to fully treat stormwater for the entire NIT South renovation without impacting available land for container operations. The design team considered many alternatives for treating the run-off of the entire 150 acre site, including conventional stormwater ponds, structural BMPs such as Vortech Units and others. In the end, none of these alternatives were capable of meeting the stormwater treatment criteria economically or without taking up valuable container yard space. The final solution was a unique and innovative solution to create a detention basin under the wharf. By driving a second steel sheet pile wall seaward of the bulkhead required for the wharf structure, and creating end walls, the design team was able to create a detention basin that was “out of sight and out of mind”. In order to meet the stormwater treatment regulations, the basin was equipped with weirs and outlet devices as necessary to create a slow release of the stormwater and meet the settling times necessary for the first 1-inch of run-off. Figures 9 and 10 in the Appendix show the placement of the under-wharf detention basin.

Creating a one-of-a-kind stormwater treatment system required nearly a year worth of effort to educate and satisfy state and federal regulators of the merits of the system, its functionality, and its ability to meet the requirements. Due to the large depth, over 30-ft, of the

detention basin maintenance to remove sediment deposits should not be required in the first 20 years of the structure's life. Large hatches were installed in the wharf deck to allow access for maintenance and inspection crews.

6. Community Concerns: NIT South is located immediately adjacent to a residential community known as Lochhaven. The Lochhaven community leaders expressed concerns about the potential impacts from noise, dust, and other construction nuisances. In addition, the community wanted assurances that the NIT South Renovations would reduce potential impacts to the waterway from stormwater run-off and potential spills on the terminal. VPA and the design team created an open dialogue with the community leaders and met with the community at annual meetings and picnics and informed the citizens of the progress of the design and construction throughout the entire project. Some of the key elements that came out of the communications were as follows:

Noise concerns: The citizens were concerned that night time pile driving would be a problem. Therefore, the specifications specifically prevented late night or early morning pile driving operations, as well as other loud construction processes. A process was put in place whereby citizens could contact the VPA Port Police at any time to file a complaint if they felt that the contractor was violating the noise restrictions. The Port Police then contacted the VPA project manager and steps were taken to stop the nuisance activities. Only a handful of complaints were filed during the 2-1/2 year construction schedule, and they were dealt with immediately to the satisfaction of the adjacent neighborhood.

Environmental Concerns: During the regular meetings with the Lochhaven citizens, VPA and the design team determined that there was concern from the citizens

that operations of the terminal negatively impacted the adjacent waterway. Neighbors believed that potential spills and regular stormwater run-off were polluting the waterway on which they lived. Through many meetings with the citizens the VPA and the design team explained how stormwater treatment devices were being incorporated into the renovations and how the VPA's stormwater pollution prevention program worked. The VPA's stormwater pollution prevention program specifically deals with potential spills and the steps necessary to prevent spills from entering the waterways. The culmination of several years of meetings was a satisfied neighborhood community.

7. No Impacts to Ship Operations: The most important criterion for the operations personnel was that the demolition and construction could not impact ship or yard operations. With over 4,200 ft of wharf, NIT South has four container berths available. Through discussions with operations personnel and analysis of ship schedules and berth utilizations at NIT it was determined that at least three berths needed to be in service at all times. The design team developed a detailed phasing plan that maintained three berths in service at all times while maximizing the available space for the contractor to work. This phasing plan required each of the phases to be of a different length, and at times placed the construction operations between active container berths (Figures 2 through 8). Properly phasing the construction was the most important aspect of this project for operations personnel and the success of the phasing plan was evidenced in the fact that there were no impacts to ship operations during the reconstruction of the wharf.

Hardware/Software Used

Industry standard computer software was used to design the NIT South Wharf Renovation, including:

- TERMSIM II, a time domain program used to analyze the dynamic behavior of a moored ship subject to wind, waves and current (the location of the wharf on the exposed, tidal outlet of the Elizabeth River complicated the analysis).
- STAAD.PRO 2002, a finite-element program used to model a 500' length of the wharf with all load combinations applied, including seismic loads.
- MICROSOFT EXCEL 2000, a spreadsheet program, with specialized macros developed in-house, was used to generate load combinations, process STAAD output, check design capacities, and graph results for various parts of the design.
- CWALSHT, a program developed by the US Army Corps of Engineers for the Design/Analysis of Sheet Pile Walls by Classical Methods was used for design of the sheet pile walls.
- COLCAP, a customized software program developed by Moffatt & Nichol, was used to generate ultimate load-interaction data for various prestressed concrete pile sections.

Project Cost

The original Design Engineer's Cost Estimate for the wharf construction was approximately \$81,400,000. The original Contractor Bid was accepted at \$79,187,758. The Final Contract Price, including all change orders, was \$83,339,243 - only a 5% increase over the bid amount. Two things contributed to this minimal overage. First, the wharf was designed in a

flexible way so as to anticipate construction problems ahead of time and allow for their solutions within the constraints of the design. For example, the flat plate design provided greater flexibility in pile driving tolerances, allowing the contractor to make monitored revisions to the new pile layout on the fly. Second, careful management of the project and budget was required, especially considering the magnitude of the project and the time frame in which it was completed.

Performance Measures

The success of the NIT South Wharf Renovation Project can be measured in the way the overall project met the criteria established for the project early on. This criteria is outlined in detail in the “Objectives and Methodology” section earlier in this submittal. For example, the new wharf now accommodates eight state-of-the-art Suez-class container cranes for more efficient container handling operations. Also, the VPA has currently dredged the berths to 50-ft and has the ability to increase that depth to 60-ft as ship sizes increase. Environmental impacts were mitigated with the implementation of an innovative “landscape approach” to fulfilling the regulatory requirements. The newest part of the existing wharf was structurally sound enough to be reused in the design of the last stage of the wharf construction, thereby eliminating the need to demolish over 1,300-ft of existing wharf structure and allowing the final stage to be completed in a very short time. Stormwater runoff was addressed with the construction of a state-of-the-art under-wharf detention basin which required no sacrifice of valuable land for container yard. Community concerns about noise and pollution were adequately addressed through a series of meetings and positive dialogue with residents. Finally, the staging of the construction allowed operations to continue at the terminal while renovations were being made. In fact, the amount of

cargo coming though NIT South actually increased during the wharf renovation and still no operational impacts were experienced. The methods by which these measures of success were realized are discussed in more detail in the following section.

How the Project Fulfills the Award Criteria

The NIT South Wharf Renovation project meets the AAPA Facilities Engineering Award criteria in that it made use of innovative engineering practices such as the under-wharf detention basin. The innovative approach to environmental mitigation was also important in helping to make the overall project a success. The engineering design of the wharf also contributed to the budget success and speed of construction of the project by reusing existing structures where possible, minimizing demolition time, and allowing for flexibility in construction.

IV. Conclusion

The VPA now has a state-of-the-art container wharf capable of serving the industry for the next 50 years. The wharf reconstruction was completed in a short time frame, 2-1/2 years, with no impacts to container and ship operations. The project was completed within budget and accrued only 5% change orders – a very low amount of change orders considering the magnitude of the renovation work, and the condition of the old structures. The environmental stormwater treatment system included in the wharf design is truly an innovative design element not found in any other project in the U.S.

Many ports in the United States are experiencing similar capacity and infrastructure issues as The Port of Virginia. The VPA's NIT South Wharf Renovation can serve as an

example of how, with proper planning and forethought, aging port infrastructure can be upgraded in a relatively short timeframe without significantly impacting operations.