U.S. CONTAINER TERMINAL THROUGHPUT DENSITY

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Quality Assurance

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INTRODUCTION

The Port of Houston Authority (PHA) retained JWD to produce this white paper, which explains how common container terminal statistics are defined and calculated. This document also explains some of the key inputs to commonly quoted statistics of throughput density per acre and how these inputs vary in different regions of the United States.

These concepts serve as a backdrop to quantify the current operation at the Port of Houston's Barbours Cut Terminal (BCT) and provide assumptions and calculations used to predict the capacity of the planned Bayport Container and Cruise Terminal.

STATISTICS OF INTEREST

In container shipping, the most basic unit of measure is the Twenty-foot Equivalent Unit (TEU). Most containers are either 20 feet long (one TEU) or 40 feet long (two TEU), and both empty and loaded containers are counted in total container volume figures. In 2002, the Barbours Cut Terminal handled a total container volume of just over one million TEU across the wharf.

The TEU is also used to define storage capacity of a container yard (CY). Container terminals in the United States typically operate with a mixture of wheeled operations and grounded operations. In a wheeled operation, containers are kept on street-legal chassis and parked in stalls so that an individual truck driver can position each one. Wheeled container yards typically store about 70-80 TEU per acre.

Terminals without sufficient space to keep all containers on wheels typically use yard cranes to stack containers in a "grounded operation." The Barbours Cut Terminal uses rubber-tired gantry cranes (RTGs) for this purpose.

Figures 1 and 2 show mixed RTG/wheeled operations at Barbours Cut and at APL's Pier 300 Terminal in Los Angeles.

Figure 1
Barbours Cut Terminal

Figure 2
APL's Pier 300 Terminal, Los Angeles

The most common sized RTG allows 1-over-4 operation where one container can be lifted over a stack four containers high. Terminals cannot achieve an average overall container height of 4.0, however, because significant space must be kept open to allow the RTG to shuffle containers in order to access the bottom container of each stack. Because RTGs cannot move efficiently with a box, each bay in cross section must allow enough space for rehandling. Most operators are only able to sustain 2.5-3.0 mean height with a 1-over-4 RTG.

Figure 3 shows a cross section of an RTG bay. Note the six vertical stacks of containers and one truck lane to the right side of the bay.

Figure 3
RTG Bay in Section View

Most RTG-based terminals in the U.S. can achieve a static density of 200-300 TEU per acre.

Because the Port of Houston handles a high volume of exports and serves many small customers through its public terminal, a high number of "sorts" is required. Export containers must be sorted by service, size, destination and weight. To permit reasonable vessel productivity, space for these containers must be reserved for arrival so that all containers for the same vessel are in the same area of the yard. This complex, export-heavy mix of cargo requires a relatively low overall stack height for efficient operations.

In contrast, terminals on the West Coast handle a smaller percentage of exports and only serve a few destinations, so their exports can be efficiently handled in large homogeneous blocks for higher density storage.

The Port of Houston also handles a higher than average volume of Dangerous and Hazardous (D&H) cargo, out-of-gage cargo (beyond the standard dimensions of a container), and refrigerated (reefer) cargo. Out-of-gage cargo must be kept on wheels. It is very desirable to keep D&H and reefer cargo on wheels to maximize the efficiency of the yard operation. The high fractions of these specialty cargoes in Houston (7% D&H vs 1% typical at most ports) limit the maximum practical static density in Houston compared to other ports.

The term "throughput density," expressed in TEU per gross acre per year, is the annual throughput divided by the size of the terminal. Most U.S. terminals operate in the range of 2,000-6,000 TEU per gross acre per year. This statistic is influenced by the following parameters:

> ***Static Storage Capacity:*** The number of containers that can fit in the terminal at any one time, expressed in TEU.
>
> ***Container Dwell Time:*** The length of time that each container spends in the terminal. The shorter the dwell time, the higher the throughput density for a given terminal. This figure is generally a function of the marketplace, little influenced by ports. Terminals on the West Coast that have large volumes of rail cargo tend to have shorter dwell times because rail cargo is typically moved off-site quickly. Local cargo at the Port of Houston may remain on the terminal site longer if shippers determine that the Port's container yard is a cheaper or more convenient storage location for their inventory than their own property.
>
> Overall dwell times for the Port of Houston are approximately seven days for loaded containers. By comparison, Los Angeles overall dwell times are approximately four days for loaded containers. A terminal in Los Angeles identical to the Barbours Cut Terminal could expect a 75 percent increase in container yard capacity due to shorter dwell times. If Barbours Cut is at capacity at 4,500 TEU per acre, a comparable terminal in Los Angeles would be at capacity at 7,900 TEU per acre per year.
>
> With its current facilities, the Port of Houston has a limited ability to reduce container dwell time. From 1998 to 2002, the amount of annual demurrage fees (charged for containers with extra long dwell times) collected by the Port increased by 1250 percent. The overall dwell time increased by 10 percent during the same period.
>
> ***Net/Gross Area Ratio:*** The amount of space available for container storage as a percentage of the total terminal. Some terminals have features like on-terminal railyards, breakbulk or RO/RO (roll-on, roll-off) handling, container freight stations (CFS) or other structures that effectively reduce the net/gross ratio. A more precise statistic for comparison would be TEU per net acre per year, but exact net acreage is rarely listed and often difficult to calculate, whereas the gross area of each terminal is widely available.

Table 1 shows the throughput density for the public section of BCT, the portion leased to APMT (a private operator), and BCT as a whole for 1997 through 2002.

	1997	1998	1999	2000	2001	2002
PHA Public Terminal						
PHA Throughput TEU	570,237	522,292	543,748	572,193	594,272	693,041
Acreage:	146.5	137.6	146.0	148.0	148.0	150.5
TEU's per Acre	3,892	3,795	3,723	3,867	4,017	4,606
APMT Terminal						
APMT Throughput TEU	231,631	274,002	322,962	329,356	317,631	370,035
Acreage:	56.4	65.3	79.9	88.9	88.9	89.0
TEU's per Acre	4,107	4,198	4,045	3,704	3,572	4,156
Barbours Cut Overall						
Total Throughput TEU	801,868	796,294	866,710	901,549	911,903	1,063,076
Total Acreage:	202.9	202.9	225.9	236.9	236.9	239.5
TEU's per Acre	3,952	3,924	3,837	3,806	3,850	4,439

Table 1
BCT Throughput Density

It is widely accepted in the U.S. container terminal operating environment that, as density increases, manning cost for grounded operations increases dramatically and will make operations uncompetetive once density exceeds the typical ranges described previously.

The behavior of APMT, the private operator, sheds extensive light on the market for container operations in Houston. Table 1 shows that, although they have experienced steady growth over the past six years, APMT has been reluctant to operate at a throughput density much in excess of 4,000 TEU per acre per year. From 1997 through 2002, the Port of Houston Authority expanded APMT's facilities by 32.6 acres, a 58 percent increase, in response to requests for more terminal area. The public terminal operated by the Port of Houston Authority only grew by three percent over the same period. APMT's actions have forced the Port of Houston to operate the public terminal at a throughput density substantially higher than appears to be economical. This constrained operation, coupled with the lack of expansion area at Barbours Cut, was the driving force behind the proposed Bayport site.

Figures 4 through 7 contribute some perspective by comparing the throughput density (TEU per gross acre per year) at Barbours Cut to terminals in Southern California, Oakland, the Pacific Northwest, and selected East Coast ports. Supporting data for these figures was compiled from the Pacific Maritime Association, the Containerization International Yearbook 2001, and various Port websites.

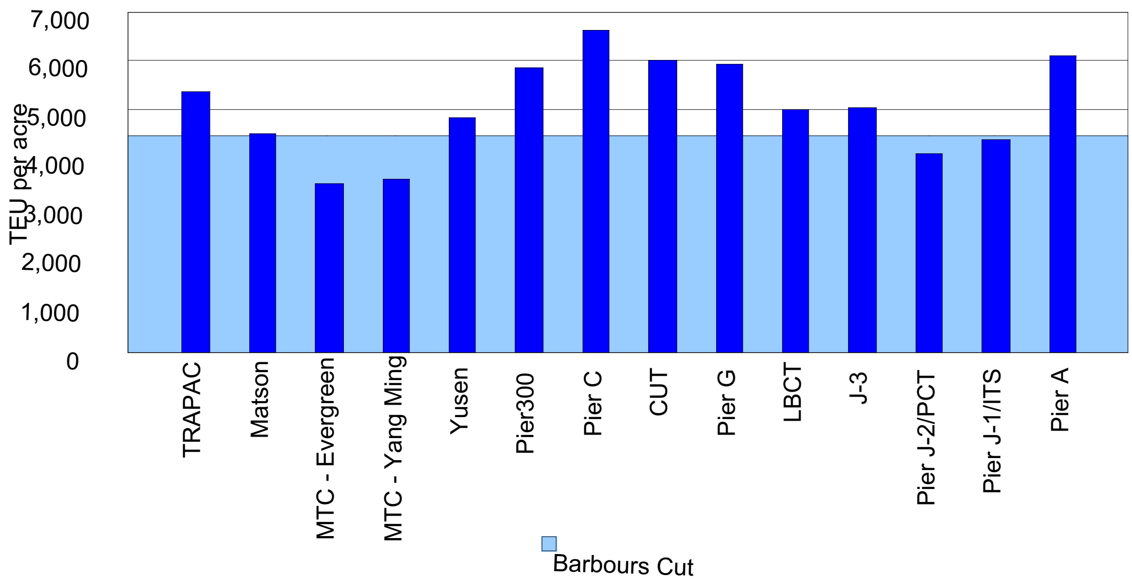

Figure 4
Barbours Cut vs Los Angeles + Long Beach Terminals

Figure 4 illustrates that several terminals are operating at substantially higher throughput densities than Barbours Cut. The primary reason for this is lower dwell times in Southern California, as previously discussed. If Barbours Cut were able to operate in a similar market to Southern California, its capacity would likely be almost 8,000 TEU per acre per year.

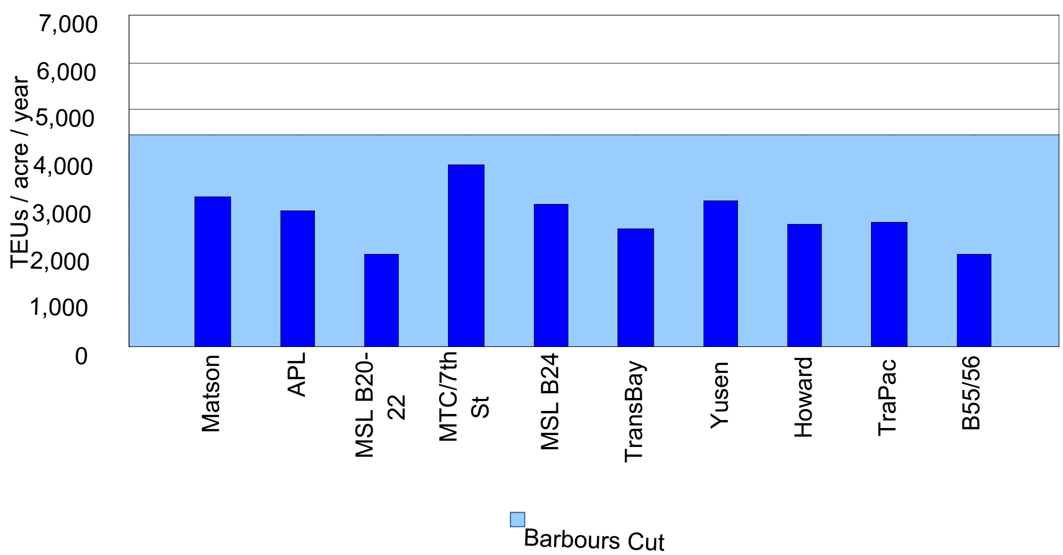

Figure 5
Barbours Cut vs Oakland Terminals

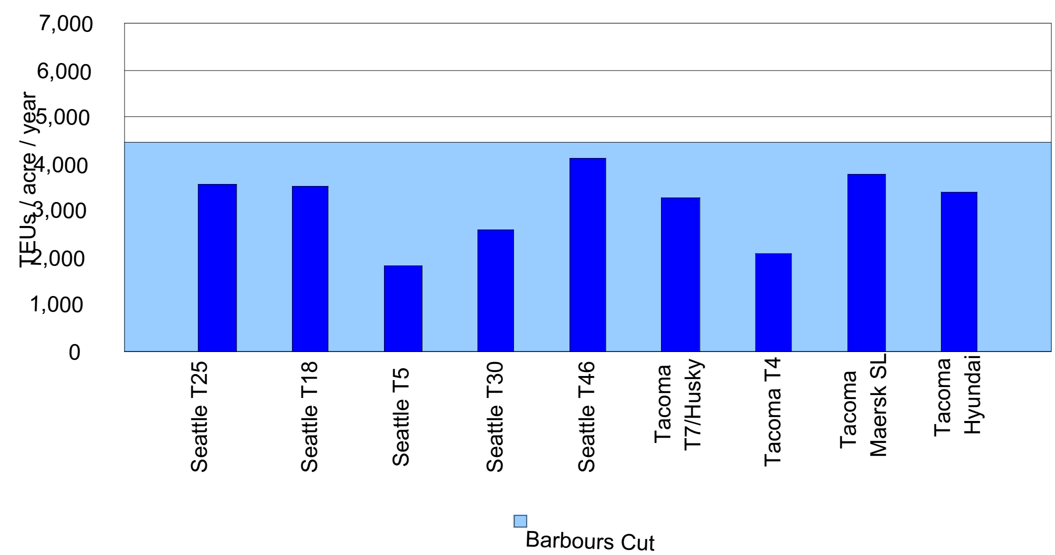

Figure 6
Barbours Cut vs Seattle and Tacoma Terminals

Note that many terminals in the Northwest, especially Seattle, are presently underutilized. Because of lower dwell times than Houston, the capacity of these terminals probably exceeds that of Barbours Cut, but unlike Barbours Cut, these terminals are not operating at levels at or near their capacity due to lack of market demand.

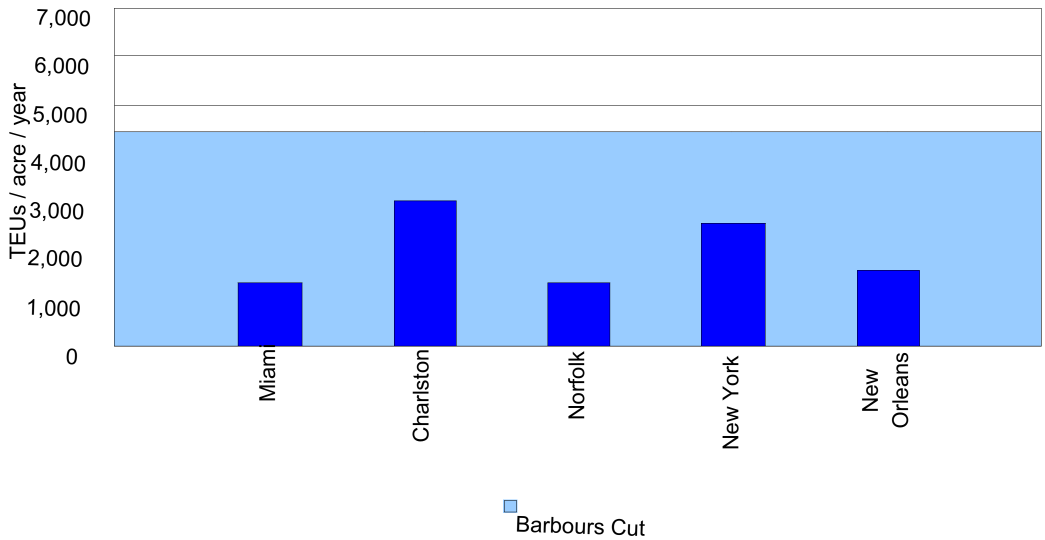

Figure 7
Barbours Cut vs Selected Gulf and East Coast Ports

Figures 4 through 7 show that, with the exception of some terminals in Southern California, Barbours Cut is among the most heavily utilized facilities in the U.S.

The Port of Oakland compares closely to the Port of Houston. They are of similar size, both serve predominantly local markets, and they handle small to medium numbers of lifts per vessel call. Figure 5 shows that Barbours Cut is operating at a higher utilization than any terminal in the Port of Oakland.

Figure 7 shows that Barbours Cut is operating at much higher throughput density than any other Gulf or East Coast ports listed. Because Barbours is in a preferred location for local cargo, it has been able to attract more throughput despite the lower density of other ports. At some point, however, shippers will choose to use alternate low density locations with lower operating costs, putting Barbours Cut at a competitive disadvantage.

THE U.S. TERMINAL OPERATING ENVIRONMENT

Cargo Flow Patterns

Because container terminal traffic is based on international trade, it is important to understand the types of trade routes appropriate for major ports in each of the three main maritime regions of the United States: West Coast, Gulf Coast, and East Coast.

The United States' biggest sea trading partners are Asia and Europe. Shipping lines have introduced ever larger vessels in order to move cargo between these regions and the U.S. more efficiently. As vessels have increased in cargo capacity, the trend has been for them to call at fewer ports and perform more lifts per vessel call at each port. Port traffic is generally divided into local cargo (which can be delivered by a truck within one day's drive) and intermodal (i.e. rail) cargo destined for more distant locations.

The U.S. interior is served by rail, and most shipping lines prefer to discharge most of their rail cargo at the first port of call. The Port of Houston is poorly positioned to be a first port of call for Asia or Europe. Asian cargo tends to flow through the West Coast, especially Los Angeles and Long Beach, the two largest container ports in the country by a considerable margin over third-placed New York/New Jersey. European cargo generally flows through East Coast ports.

Houston, as the dominant port in the Gulf region, is well positioned to serve the Caribbean and South America. Houston's geographic position is important for two reasons:

1. Smaller market ports served by Houston result in smaller numbers of lifts per vessel call than in major first-call ports for dominant U.S. trading centers. These small ship calls require lower container yard storage densities for efficient operations.

2. Traffic flowing through the Port of Houston primarily serves the State of Texas, compared to ports like Tacoma where over half of all imports move via rail to distant destinations. Because of this, container dwell times tend to be longer in Houston than in other ports.

Figure 8 shows three example service routes for Maersk-Sealand Lines, one of the world's major shipping lines. Maersk-Sealand is served at Barbours Cut by APMT.

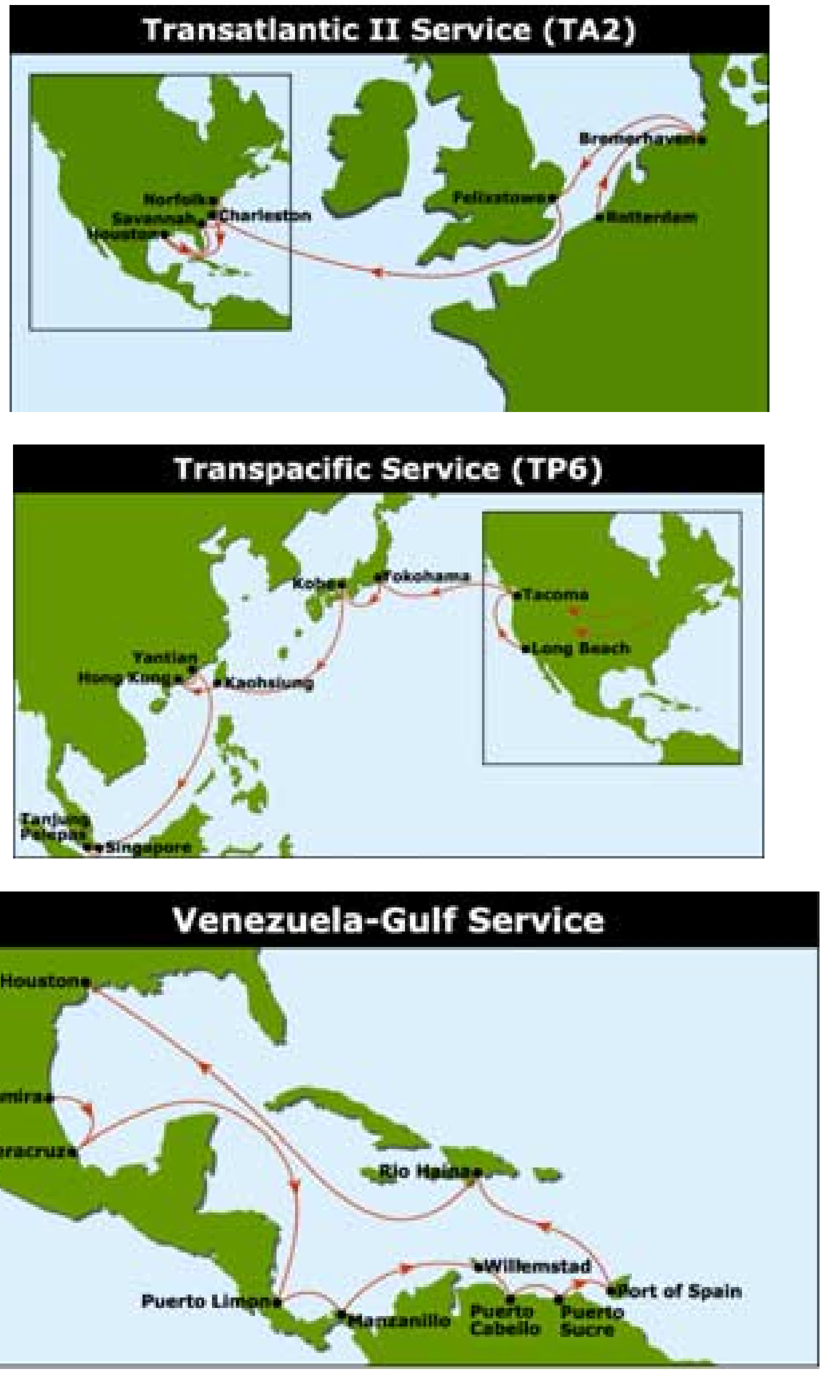

Figure 8
Example Major Carrier Vessel Call Pattern

Terminal Labor and its Impact on Operations

The labor force at U.S. container terminals is controlled by a small number of powerful unions. U.S. dockworkers are among the highest paid blue collar workers in the world, and they exercise significant control over how work is done and how many people are required to operate terminal equipment.

Because of this high cost and low flexibility, U.S. container terminal operators have generally preferred to operate in a wheeled mode because this type of operation requires the least amount of labor. When a terminal is forced to use a high degree of grounding using RTGs or other equipment, the terminal operator typically begins to seek opportunities to move to a larger location in order to reduce the manning cost of the operation.

The APMT terminal at Barbours Cut is an interesting example of market forces at work. Although this is the only private terminal at the Port of Houston, private terminals are the norm at many U.S. ports. The Port leases APMT the terminal site for a flat rate, and APMT is free to choose its operating mode.

At first glance, this rate structure would seem to encourage AMPT to operate a very dense terminal with a high storage capacity, dividing its fixed rent by a higher throughput and lowering the rent cost per container handled. But in actuality, as the density of the container yard rises, the labor cost per container moved for high-density grounded operations rises faster than the rent cost declines.

The Port of Los Angeles recently constructed the world's largest dedicated terminal at Pier 400 for APMT so that they could move from a highly grounded operation to a predominantly wheeled system. APMT will move from an operation of approximately 6,000 TEU per acre per year in Long Beach to about 4,000 TEU per acre per year at startup at Pier 400. On the West Coast, the ports of Long Beach, Oakland, and Tacoma have also constructed or are in the process of constructing large new terminals to enable private operators to work at a lower density.

BAYPORT

As part of the Bayport Container and Cruise Terminal master plan, JWD worked with the Port of Houston Authority to develop a terminal that was balanced in its berth and container yard capacity. The berth capacity of the 7,000-foot wharf face was analyzed as approximately 1.4 million container lifts per year. The Port currently predicts a distribution of about 60 percent 40-foot containers and 40 percent 20-foot containers, for an overall 1.6 TEU per container ratio. This berth capacity can also be expressed as 1.4 * 1.6 = 2.24 million TEU per year.

JWD and the Port of Houston Authority planned Bayport with the overall assumption that market forces that apply to Barbours Cut would also apply to Bayport. In other words, the container dwell times would be relatively long and the operating heights and preferred RTG versus wheeled fraction would not change significantly from Barbours Cut.

Numerous support facilities and features were incorporated into the Bayport master plan to create a full-service container facility with high environmental standards and strategies for minimizing the impact on the neighboring community. These included:

Large intermodal railyard

Numerous container freight stations (CFS) to support the marine and intermodal terminals

On-site storage yard for empty containers that are now handled off-site at Barbours Cut

Retention ponds for the collection and temporary storage of storm water to minimize pollution from run-off

Buffer zones of undeveloped land between the terminal and the adjacent community

Large berms to block noise and sound from the terminal

In addition to these features, the Bayport terminal complex also includes a three-berth cruise terminal and support areas.

The total size of the planned Bayport terminal complex is 1,043 acres. Dividing the container terminal capacity by the size of the entire complex results in a very low throughput density of 2.24 M / 1,043 = 2,150 TEU per acre per year.

It is important to make an "apples-to-apples" comparison between Bayport and other terminals. Most container terminals have a net to gross container yard ratio of 65% to 80%. This represents the ratio between the area used to store containers (and related circulation space) compared to the total terminal area. The other 20 to 35 percent of each terminal consists of the wharf, gate, buildings, parking lots, and railyard, if applicable.

Figure 9 shows a breakdown of land area by use for terminals in the Port of Los Angeles. The percentage of net container yard at each terminal is listed in the graphic.

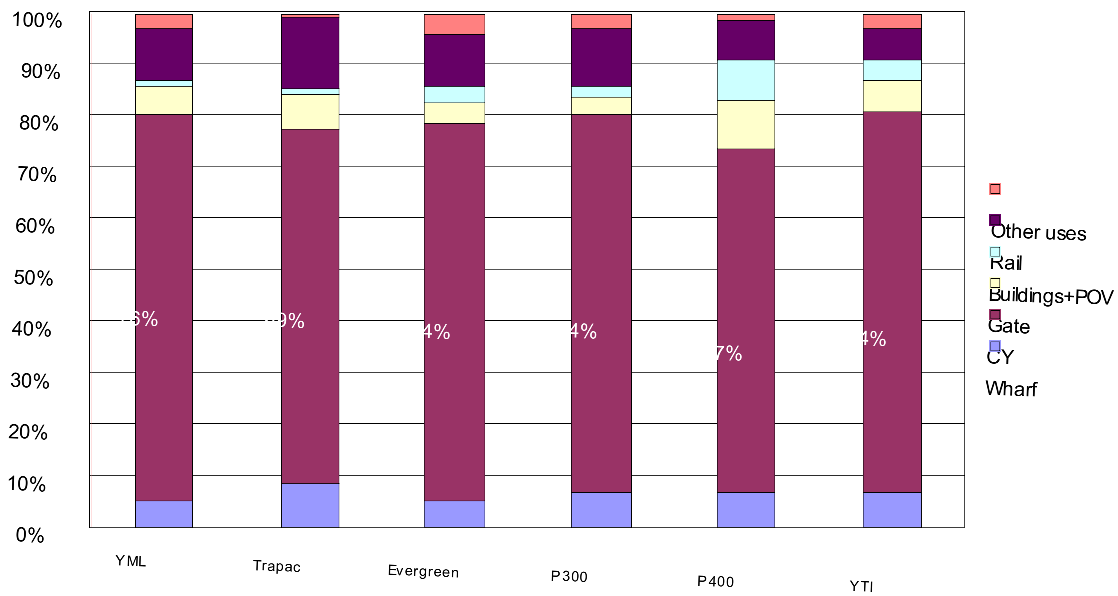

Figure 9
Composition of Terminal Areas – Port of Los Angeles

The net container yard area at Bayport is 378 acres, 72 percent of the gross facility area of 526 acres (without the intermodal yard). This ratio is similar to most terminals in Los Angeles, as shown in Figure 9. Using this area to calculate Bayport's expected throughput density at capacity yields a value of 2.24M/ 526 = 4,260 TEU per acre per year. This throughput density is higher than has ever been achieved at Barbours Cut by the private operator APMT.

CONCLUSIONS

Certain elements of the marketplace for container traffic in Houston tend to limit operations to lower capacities than markets on the East or West Coasts. These factors include:

Long dwell times due to predominantly local market

Export customer requirements that result in numerous "sorts" and low-density stacking to retain efficiency

High fraction of D&H, out-of-gage, and reefer cargo that must remain on wheels

Despite these constraints, the Barbours Cut terminal is operating at one of the highest throughput densities in the United States. The Port of Houston must expand its facilities in order to efficiently accommodate further container traffic growth.

The Bayport terminal was planned to be a balanced, full-service terminal that operates with a minimum negative impact on the environment and the community. Although Bayport was planned to operate at a throughput density similar to Barbours Cut, with the container yard capacity in balance with the berth capacity, there is nothing inherent in Bayport's design that limits its capacity to this figure. The flexible design will enable Bayport to handle higher densities imposed by the market without requiring additional investment in infrastructure.

APPENDIX – RESPONSE TO THE GBCPA'S TECHNICAL REPORT

This section responds to issues raised in the January 7, 2003 Technical Report on Space Efficiency in Container Ports issued by the Galveston Bay Conservation and Preservation Association (GBCPA).

The report presents a table of throughput densities that compares Barbours Cut and Bayport to other ports. Instead of using recent actual throughput statistics, this report uses a nominal "capacity" statistic for each port other than Barbours Cut. No clarification was given about how these capacities were generated, so it is impossible to comment on the validity of each assumption.

In the case of Long Beach and Seattle, the capacities are significantly higher than recent throughput. Table A.1 compares the GBCPA's capacity figure with the 2002 throughput at each port as reported by the Journal of Commerce.

	Long Beach	Seattle
2002 Throughput (million TEU)	4.5	1.4
"Capacity" as listed in the GBCPA report (million TEU)	6.5	3.2
Capacity/2002 Throughput	1.44	2.29

Table A.1
2002 Throughput vs GBCPA's Capacity

At a 5 percent growth rate, it will take the Port of Seattle 17 years to reach its current "capacity" as listed in the GBCPA report.

The 500-acre area listed for Barbours Cut is substantially greater than the 240 acres of terminal area quoted by the Port of Houston Authority. Barbours Cut is approximately rectangular in shape, with 6,000 feet of wharf and a typical depth from the wharf face to Barbours Cut Boulevard of 1,600 feet. A simple area calculation based on these rough dimension yields 220 acres of terminal area. When areas beyond this basic rectangle are added and the cemetery within the rectangle is subtracted, 240 acres of terminal area seems correct for what is traditionally considered terminal property. How GBCPA came up with 500 acres for Barbours Cut is unclear. In all likelihood, they included facilities not included in area calculations for other ports and terminals.

The same table in the GBCPA report that compares an inflated capacity of Long Beach and Seattle to recent throughput at Barbours Cut also overstates the size of Barbours Cut by a factor of more two, thus underreporting the throughput density by the same amount. Refer to Figures 4-7 for a comparison of recent actual throughput densities at Barbours Cut versus major U.S. ports. As stated in the white paper, with the exception of Southern California, where terminals serve a different market than Houston, Barbours Cut is one of the most heavily utilized facilities in the United States. It should also be noted that many major U.S. ports, including the Los Angeles and Long Beach, are spending hundreds of millions of dollars to develop larger terminals so that operators can reduce their throughput densities and therefore reduce their operating costs.

The GBCPA report uses an area figure of 899 acres to calculate the throughput density of Bayport. This figure includes many areas that do not exist at comparable facilities. Items such as undeveloped buffer space, retention ponds for water pollution control, sound and light blocking berms, etc., are non-existent in Seattle or Long Beach and unfairly skew the comparison. As indicated in the white paper, a valid comparison would include only 526 acres of the Bayport complex and would yield a throughput density of 4,260 TEU per acre at capacity.

The Bayport planning team, led by JWD, was responding to various goals when it developed the master plan for Bayport. The terminal could ostensibly be smaller and still handle the same throughput if the community was willing to accept increased traffic and air pollution resulting from additional truck traffic to off-site railyards, CFS warehouses, empty container storage depots, more light and noise, and more water pollution in Galveston Bay. Throughput density was not the overriding factor in the development of Bayport. The available parcel of land was master planned to provide a balanced, high capacity container terminal for full service to the shipping community and also allowed for the expansion of the cruise business in Houston, while minimizing the impact on the environment and the community.