Port of Corpus Christi Authority

Waterway Planning Study of the Corpus Christi Ship Channel System

FINAL REPORT

Jan 15, 2019

Quality information

Prepared by	Checked by	Approved by
Mark Sisson	Marisa Araujo	Mark Sisson Project Manager

Revision History

Revision	Revision date	Details	Authorized	Name	Position
1	Oct 22, 2018		Mark Sisson		
2	Oct 25, 2018		Mark Sisson		
3	Jan 15, 2019		Mark Sisson		

Prepared for:

Port of Corpus Christi Authority

Prepared by: AECOM

Executive Summary

This report summarizes the procedure and results from AECOM's recent capacity analysis of the ship channel at the Port of Corpus Christi (POCC). This project is an update of the original study undertaken in 2016-17. The primary reasons for this upgrade are incorporation of more powerful simulation models, and the ability to incorporate fresh projections for future projects and cargo volume at the Port, which is experiencing very strong growth especially in the crude oil export sector.

This study, like the original, was based on analysis done with AECOM's proprietary Vessel Network Model (VNM). VNM now allows for dynamic draft change for each vessel as cargo is loaded or unloaded, and allows for vessels to release capacity for a channel segment prior to physically leaving this segment, in order to more closely mimic actual pilot behavior.

Using historical data from the Port's operations in the first quarter of 2018, and published vessel statistics from the Seaweb database, AECOM developed estimates of the amount of cargo each class of vessel of Aframax size or larger could carry at a maximum draft of either 45' or 52'. These capacity values were combined with near term vessel projections from the Aransas Pilots, and information from the POCC commercial dept on new projects to develop the 2023 forecast.

The 2028 forecast was developed by scaling up operations, primarily involving crude oil export, to match projections from the recent EAI study. Exports of crude oil are experiencing very strong growth rates and are the primary driver of overall volume growth at the Port. Market projections are based on best available data as of late summer 2018.

AECOM analyzed cases for channel depths that allowed a maxmum vessel draft of either 45' or 52'. In each case the total number of vessels were held constant, but the -52' scenario allowed for more annual cargo movement due to the higher capacity of each ship. Figure E.1 shows the volume of ships modelled by year and vessel class.

Figure E.1. Number of ships modelled per year.

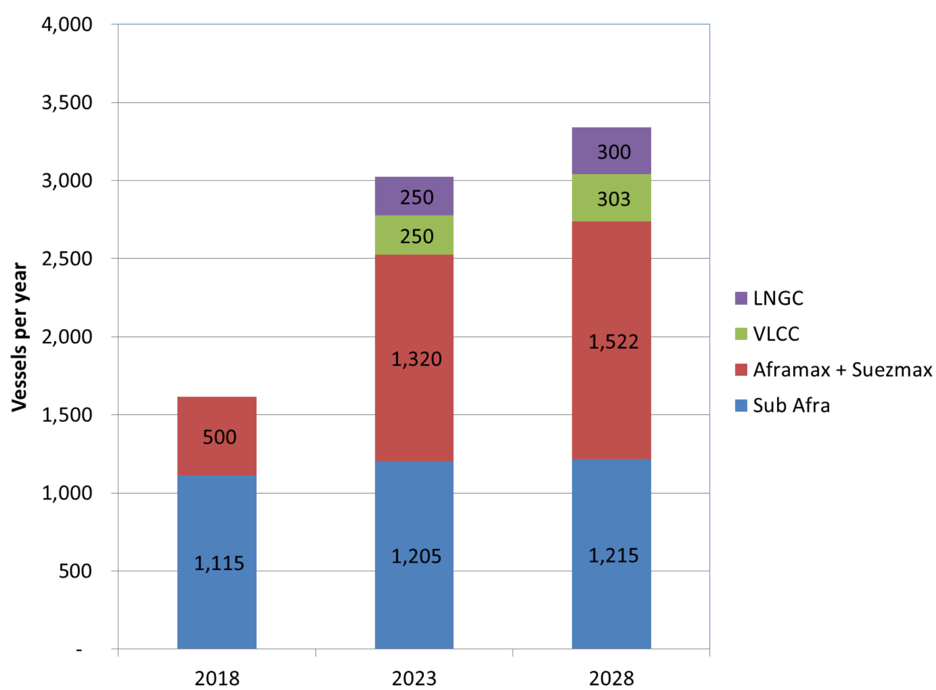
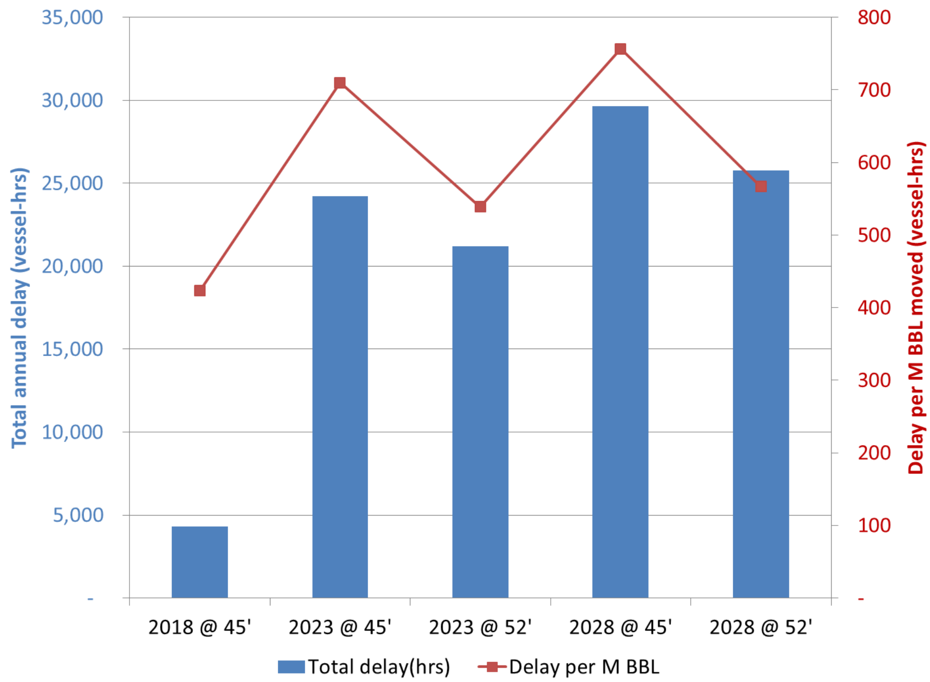


Figure E.2 shows the summary of results, in terms of total annual hours of channel related delay as well as hours of delay per million BBL moved.

Figure E.2. Base Case Results Summary.



Conclusions –The main findings from this study are listed below:

1. The Port expects to handle a great deal more cargo in the near future than it does today.

2. Nearly all of this new cargo will be handled by large ships that cannot move at night, and many of which cannot meet any other vessels in the channel, regardless of channel size.

3. These restrictions lead to a large increase in channel delay compared with 2018 that is only modestly improved by increasing the channel size.

4. Allowing Suezmax or LNGC vessels to travel at night will substantially reduce overall delay.

5. The primary benefit of a deeper channel is not a radical reduction in vessel delay (unless it allows for relaxation of night travel limits), but the ability to better utilize large ships and move significantly more cargo with the same number of ships.

6. There is a good deal of uncertainty around the shore-side capacity limits of existing terminals, and this may be a good area for future study.

Table of Contents

Figures

Tables

1. Introduction and New Model Features

This study is a follow up to AECOM's original study done in June 2017 for the Port of Corpus Christi. Both studies are based on analysis of harbor operations with AECOM's vessel network model (VNM). This current study includes simulating port operations in detail, linking cargo volume to specific vessel events, developing a range of plausible medium term scenarios for organic growth of existing terminals and new terminals. This project update also compares port operations with and without dredging the channel and analyzing sensitivity to various alternate working rules.

The primary motivation for this update is to be able to use the new VNM model features to accurately model the traffic projections for the Port of Corpus Christi in the next five and ten years (2023 and 2028).

Table 1.1 shows the definition of the project and no project conditions analyzed, which are unchanged from the previous study. The pinch point at ADM and Citgo 1 in the Inner Harbor was set at 377' in all simulated cases.

Table 1.1. Channel Dimensions With and Without Dredging

	Existing	With Project
Cut A allowable combined beam (ft)	265	316
Cut B allowable combined beam (ft)	215	316
Max vessel draft (ft)	45	52
Maximum combined vessel draft (ft)	80	90

Table 1.2 shows a summary of the assumed vessel sizes and operating rules which were provided by the Port of Corpus Christi pilots. These are unchanged from the original study with the exception of the addition of the VLCC category as no VLCCs were modelled in the previous study. The information on pilot and tug use is for information only. As with the previous study, AECOM has assumed that lack of pilots and tugs will not constrain port capacity. The fractional example pilots and tugs in Table 1.2 are based on input from the Aransas Pilots and represent averages for each vessel type based on vessel size and draft. The actual number may vary based on cargo and wind conditions.

Table 1.2. Vessel Size vs Pilot and Tug Assignment

Rule	VLCC	LNGC	Suezmax	Aframax	Panamax	Handy	Sub-handy	ATB (Ocean Barge)
Tugs inbound	5	4	3	2.5	2	2	2	1
Tugs outbound	5	4	3	2.5	2	1.5	1	1
Pilots @ day	3	2	2	1.5	1	1	1	1
Pilots @ night	NA	NA	NA	2	1	1	1	1
Typical beam (ft.)	200	154	158	138	106	90	75	75
Daylight only Y/N	Y	Y	Y	Y for 40.9'+	N	N	N	N

1.1 New Features in VNM Model

1.1.1 Dynamic Draft Calculations

The VNM model update features include dynamic draft calculations and refined channel capacity reservations per vessel, to more closely simulate port operations. Vessels can be shown with color indicating draft during the model run, with darker colors indicating more draft. The user can watch a ship change color as cargo is loaded or unloaded. Figure 1.1 shows an example of this animation feature.

Figure 1.1. An Example of the VNM Modelling the Dynamic Draft Feature.

Each vessel in VNM is defined with a factor that describes how much the vessel's draft will change with a ton of cargo added or removed. In addition each vessel service has a defined amount of ballast carried, which is assumed to be exchanged prior to any net change in draft. As an example, consider a vessel with a shape that allows for one foot of draft change per 26,400 BBL that arrives empty of cargo with a draft of -25' and 198,000 BBL of ballast, and loads 660,000 BBL of cargo.

As the first 198,000 BBL of ballast are pumped out and exchanged for cargo, the vessel remains at -25'. Once all the ballast has been exchanged, the vessel then begins to sink in the water. The 462,000 BBL of cargo loaded after all the ballast has been exchanged will cause the vessel to sink 462,000/26,400 = 17.5' farther into the water, resulting in a departing draft of -25'-17.5' = -42.5'. With the current channel limit, this vessel will now be unable to meet any other vessel with a draft below -37.5'.

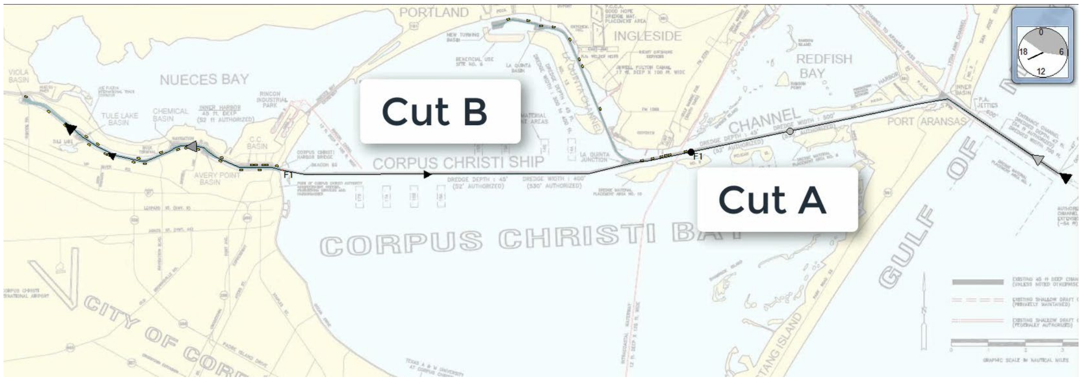
1.1.2 Look Ahead Feature

The other major upgrade to VNM compared with the original study was the addition of a "look ahead" ability to allow vessels to release capacity prior to actually leaving a particular section of channel. This is most relevant for the existing channel where Cut A is wider than Cut B. As an example, consider an outbound Panamax and inbound Aframax vessel. These can meet in Cut A but not Cut B.

In real life, pilots will start in with the Aframax vessel while the Panamax vessel is still in Cut B, knowing that by the time the two vessels meet, both will now be in Cut A. The previous version of VNM could not replicate this "look ahead" behavior and was therefore extra conservative. This current version now includes a user specified look ahead distance that is used for calculations on channel capacity. VNM shows this by linking a look ahead circle to each vessel, indicated by a triangle.

Figure 1.2 shows an example of this logic where the black Panamax vessel is physically still in Cut B, but its projected location circle is now in Cut A. This has allowed the grey Aframax to begin travelling in from the anchorage point.

Figure 1.2. Example of the VNM Model's Look Ahead Feature.



2. Vessel size and cargo carried

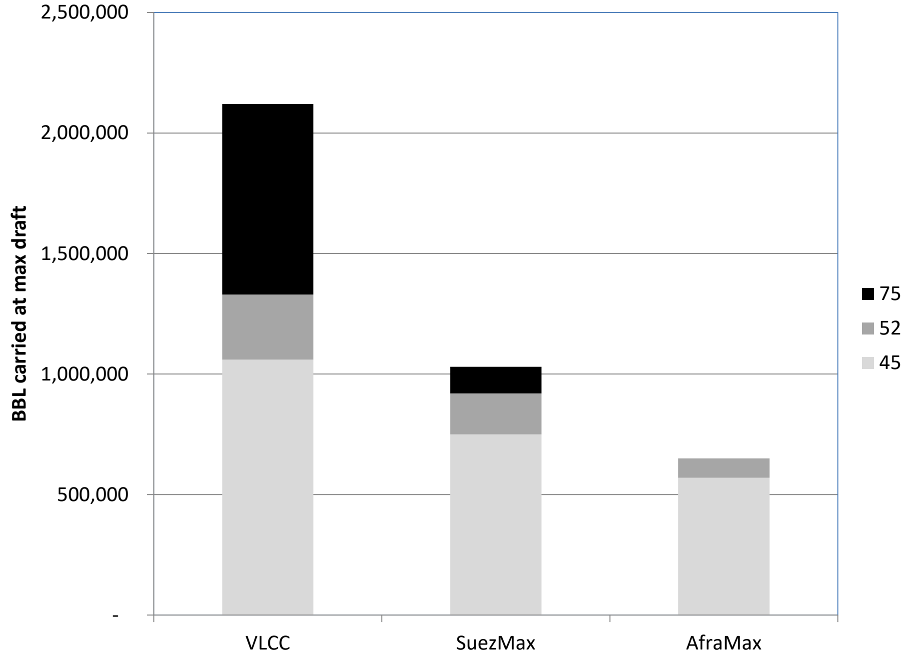
AECOM used vessel data from the Seaweb database and information provided by the Aransas pilots to calculate the typical cargo parcel sizes carried for vessels of Aframax and larger. Table 2.1 shows the calculations in detail. For future volume projections we have assumed that vessels serving new terminals will load to 100% of capacity. The assumed capacity per vessel is shown in bold in this table. Note that not all ships of the same class are identical in size. These are nominal calculations that represent typical capacity by vessel size.

Table 2.1. Calculations for Physical Capacity for Each Vessel Class at Various Channel Depths.

	VLCC	Suezmax	Aframax	
	2,200,000	1,100,000	700,000	BBL Capacity
	1050	900	800	Typical LOA (ft)
	197	158	138	Typical Beam (ft)
	91%	85%	84%	Typical Rectangle Factor
	187,879	120,870	92,736	Area at Waterline (sf)
	0.0320	0.0320	0.0320	Water Weight (tons per cf)
	39,702	25,542	19,596	BBL per foot displacement
	654,000	317,000	218,000	Ballast Capacity (BBL)
	70%	75%	75%	Max Ballast Exchange as % of Ballast Capacity
	457,800	237,750	163,500	Ballast Exchange (BBL)
	30.0	25.0	24.0	Minimum Draft (ft) fore + aft mean
	71.9	56.0	49.0	Maximum Draft (ft)
Channel Depth (ft)	41.9	31.0	25.0	Maximum Delta Draft (ft)
45	15.0	20.0	21.0	Maximum Delta Draft w 45' Channel (ft)
52	22.0	27.0	25.0	Maximum Delta Draft w 52' Channel (ft)
75	41.9	31.0	25.0	Maximum Delta Draft w 75' Channel (ft)
45	**1,060,000**	**750,000**	**570,000**	Max Cargo @ 45' (BBL)
52	**1,330,000**	**920,000**	**650,000**	Max Cargo @ 52' (BBL)
75	2,120,000	1,030,000	650,000	Max Cargo @ 75' (BBL)

Figure 2.1 shows the maximum capacity for each vessel, including Aframax and Suezmax vessels.

Figure 2.1. Vessel Cargo Capacity vs Draft



Although the primary focus of this study was a comparison of channels capable of allowing 52' vs 45', we have also analyzed a sensitivity case with an extra deep channel to Harbor Island to allow for VLCCs to travel at up to 75' of draft. Figure 2.1 illustrates the appeal of this scenario as over 660,000 extra BBL of cargo can be loaded into a VLCC at this depth.

Even at -52' maximum draft, VLCCs can still load a considerable amount of cargo (approximately 2/3 of their total capacity) at berth, and our analysis assumed that the Port would see the same number of VLCCs regardless of channel depth. With the -52' draft limit, VLCCs would be reverse lightered (topped off) at sea using shuttle tankers of Suezmax or Aframax capacity. Figure 2.2 shows an example of this activity.

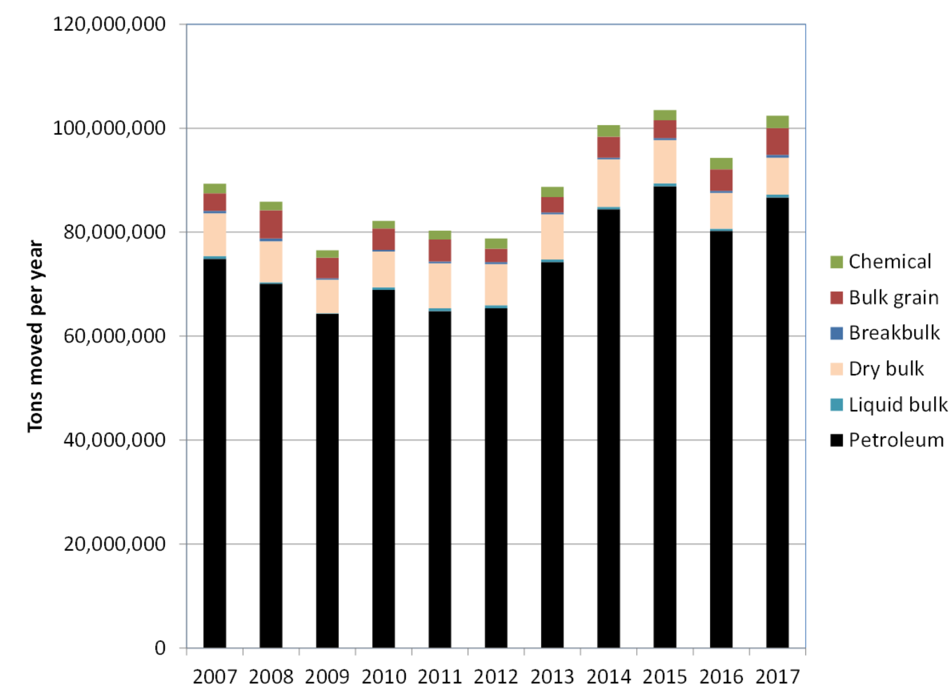
Figure 2.2. Reverse Lightering Example

3. Historical Data and Future Cargo Forecast

3.1 Historical Data

AECOM used the data that was presented on the Port of Corpus Christi website to develop Figure 3.1, which represents the overall annual volume by cargo type from 2007-2017. This chart shows cargo moving in both directions and includes cargo carried by coastal barges as well as ships and ocean barges. Figure 3.1 lists six categories of cargo and indicates that petroleum is the dominant category of cargo at the Port.

Figure 3.1. Annual Overall Volume by Cargo Type from 2007-2017.



Figures 3.2 and 3.3 are also taken from the Port's website and show a more detailed breakdown of cargo types flowing in each direction for both 2016 and 2017.

Figure 3.2. 2016 Volume by Commodity.

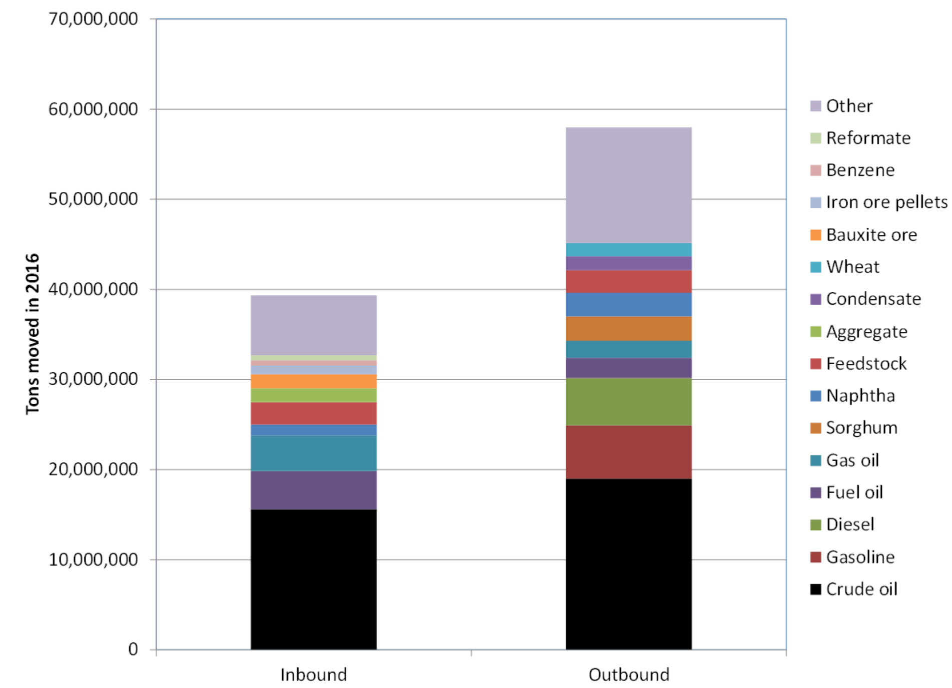
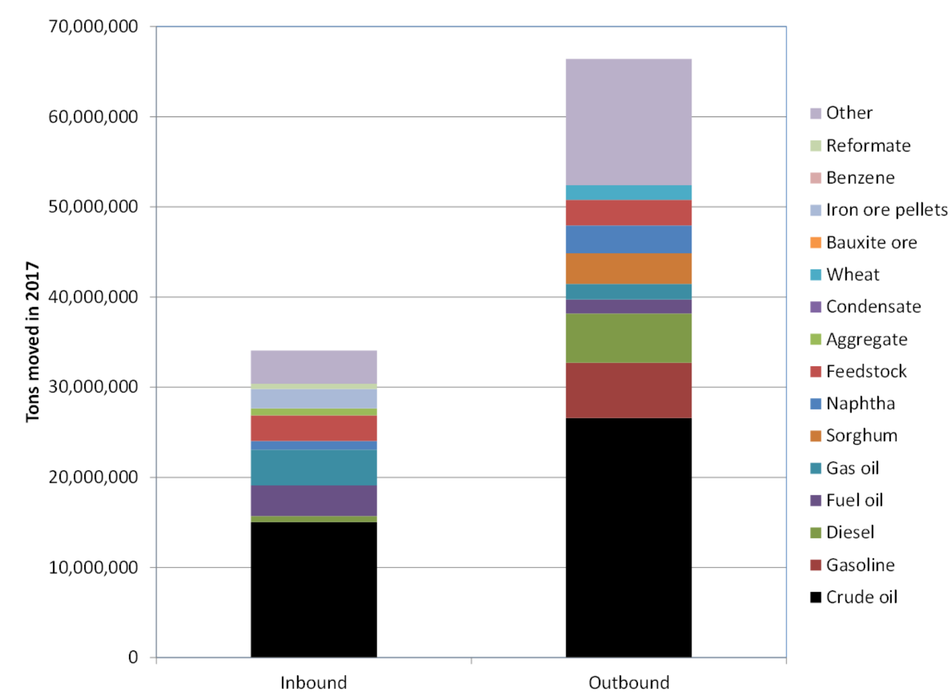


Figure 3.3. 2017 Volume by Commodity.



A comparison of Figure 3.2 and 3.3 shows the significant increase in crude oil exports that took place in 2017. It only recently became legal to export crude oil from the US so this industry is still very young and experiencing dynamic growth as new oilfields are developed and new pipelines are constructed. Corpus Christi is conveniently located to major crude production regions in Texas and expects to continue to export increasing levels of crude oil for the foreseeable future.

Figures 3.1 – 3.3 include cargo moving on coastal barges, which do not require pilots for navigation and generally use separate facilities from deep sea vessels. Because of this minimal physical interference between coastal barges and larger vessels, we have not modelled coastal barges in detail. This approach is consistent with the original simulation study. Figure 3.4 shows the fraction of cargo moved via coastal barge at each terminal in Q1 2018. Terminal names are not shown but they are sorted by volume with the busiest at the left. Most terminals are either dedicated to coastal barges exclusively, or rarely handle them, so there is a very low level of interference between coastal barges and other vessel types at berth.

Figure 3.4. Fraction of Terminal Volume via Coastal Barge.

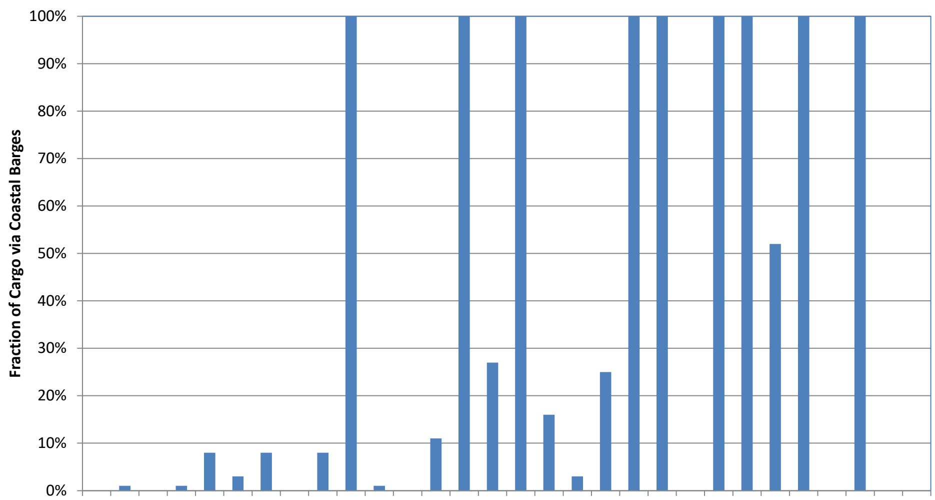
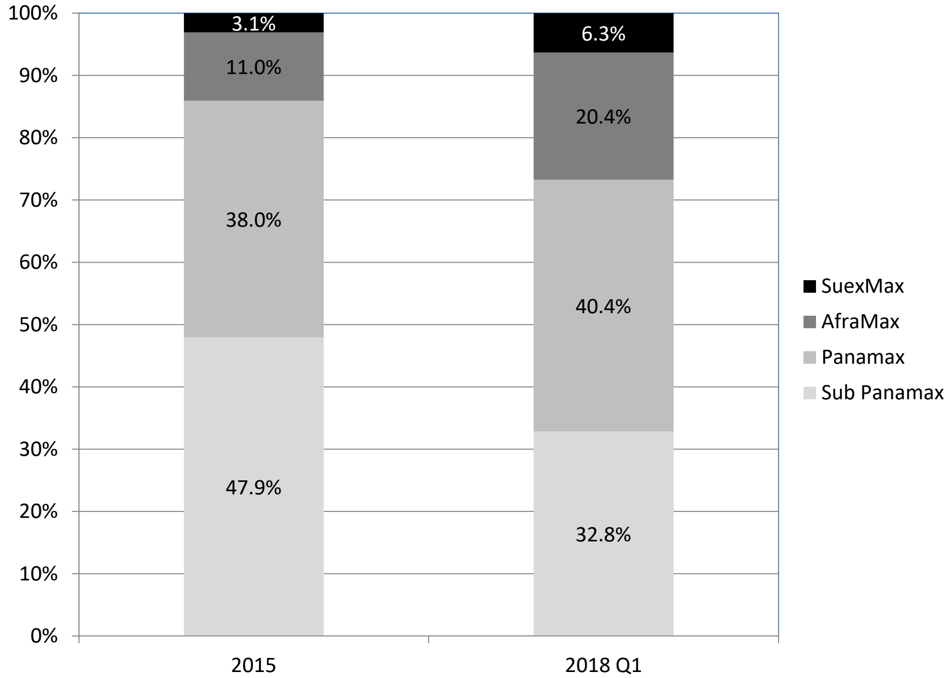


Figure 3.5 shows a comparison of vessel sizes for 2015, which was used as input in the previous study, with first quarter of 2018. This shows a fairly strong trend toward shift to larger vessels even without any change in channel dimensions. The fraction of Suezmax vessels calling at the Port has doubled in this time period, for example.

Figure 3.5. Mix of Vessel Sizes



3.2 Future Forecast

The 2023 vessel forecast was generated primarily from vessel projections given by the Aransas pilots, and augmented with projections from individual terminal operators. The bulk of the new traffic in the Port is the result of additional crude exports. The LNGC facility operated by Cheniere will also generate a significant number of future vessel moves. The figures 3.6 and 3.7 show the physical location of future facilities. The red squares indicate existing operations whereas the black squares indicate expected future operations.

Figure 3.6. Port of Corpus Christi Inner Harbor Map

Figure 3.7. Port of Corpus Christi La Quinta Channel and Harbor Island Terminals

Table 3.1 shows terminals that can handle Suezmax and VLCC vessels.

Table 3.1. Terminals that can handle Suezmax and VLCCs

Terminals	Suez (capability)	VLCC (capability)
Moda Midstream	X	X
Buckeye (STG)	X	X
Harbor Island	X	X
Plains All American	X	
CC Polymers & Pin Oak (OD 14)	X	
Magellan	X	
CCI (OD 22)	X	
Citgo # 3	X	
Valero #2	X	
Valero #3	X	
POCCA Oil Dock #1	X	
Buckeye #1	X	
Flint Hills 4 Ingleside	X	
POCCA Oil Dock #15 (Utilized by NuStar)	X	
POCCA Oil Dock #4	X	
POCCA Oil Dock #7	X	
POCCA Oil Dock #11	X	

Table 3.2 shows a detailed breakdown of the new vessel traffic modelled for 2023, and the corresponding amount of cargo moved with a maximum draft of either -45' or -52'.

Table 3.2. 2023 New Terminal Activity Summary

2023 Crude Oil Projection

Terminal	VLCC/yr	Suez/yr	Afra/yr	BBL per day @ 45'	BBL per day @ 52'
Plains		60	20	154,000	188,000
Moda Midstream	100	100	100	651,000	798,000
CC Polymers & Pin Oak (OD 14)		60	20	154,000	188,000
Magellan		60	20	154,000	188,000
CCI (OD 22)		60	20	154,000	188,000
Buckeye (STG)	50	50	50	326,000	399,000
Harbor Island	100	100	100	651,000	798,000
2023 Total	250	490	330	**2,244,000**	**2,747,000**

2023 Other

Terminal	LNGC/yr	Panamax/yr	Handymax/yr	Tons/year @ 45’	Tons/year @ 52’
Cheniere	250			22,500,000	22,500,000
Exxon (GCGV)		60		1,800,000	1,800,000
GCCM (cement)			30	600,000	600,000

AECOM believes that new crude export terminals can load Suezmax vessels at a rate of 40,000 BBL/hr (6,000 tons/hr). If loading can be done for perhaps 10 hour per day (with other time for vessel moor/unmoor or idle), this means that the daily loading capacity of approximately 400,000 BBL is reasonable. This is well in excess of the projected throughput at many terminals shown in Table 3.2.

For the 2028 Forecast, AECOM matched the recent middle overall Port-wide estimate from EAI of 3.8M BBL/day. The Port is currently handling 0.5MBBL per day so 3.3M BBL/day of new crude exports are expected per this study. Only 2.7M of new crude volume is shown in Table 3.2. AECOM developed the 2028 forecast in Table 3.3 by increasing volume at the lower volume new terminals from the 2023 forecast that we believe are operating well below capacity.

Table 3.3. 2028 New Terminal Activity Summary

2028 Crude Oil Projections

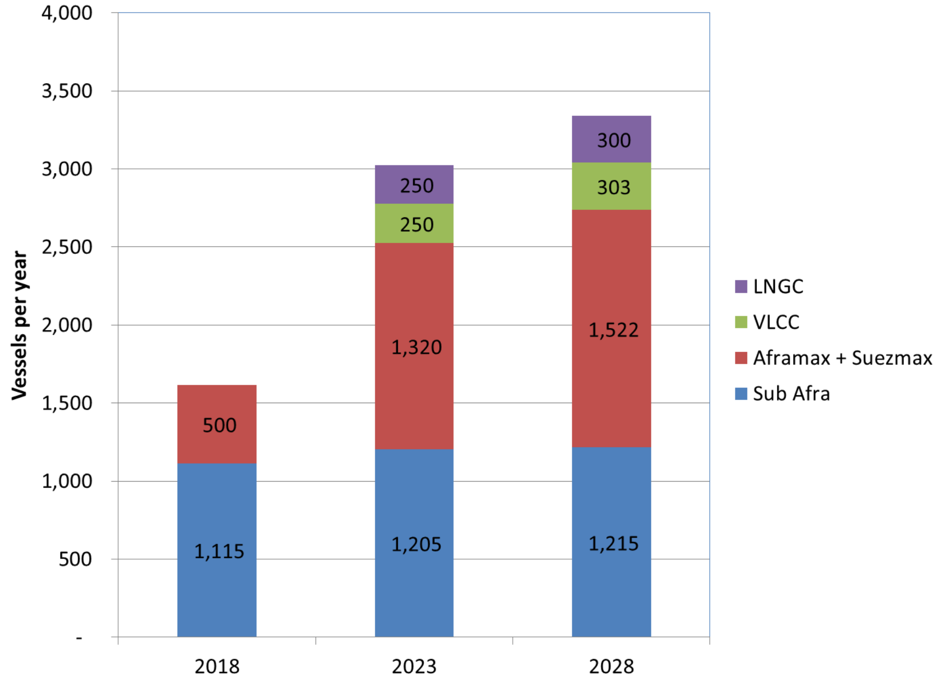
Terminal	VLCC/yr	Suez/yr	Afra/yr	BBL per day @ 45’	BBL per day @ 52’
Plains		78	26	200,000	244,000
Moda Midstream	100	100	100	651,000	798,000
CC Polymers & Pin Oak (OD 14)		78	26	200,000	244,000
Magellan		78	26	200,000	244,000
CCI (OD 22)		78	26	200,000	244,000
Buckeye (STG)	103	103	103	671,000	822,000
Harbor Island	100	100	100	651,000	798,000
2028 Total	303	615	407	**2,773,000**	**3,394,000**

2028 Other

Terminal	LNGC/yr	Panamax/yr	Handymax/yr	Tons/year @ 45’	Tons/year @ 52’
Cheniere	300			27,000,000	27,000,000
Exxon (GCGV)		60		1,800,000	1,800,000
GCCM (cement)			40	800,000	800,000

Figure 3.8 summarizes the total number of vessels per year for each base case model. This number does not change for the deeper channel, but the deeper channel does allow more cargo to move per vessel as described in Table 3.2 and 3.3.

Figure 3.8. Total Cargo Volume by Vessel Class



4. Simulation Results

4.1 Fundamental logic

Although new features have been added to the VNM model as described in Chapter 1, the fundamental logic of AECOM's VNM model is largely unchanged from the previous study. AECOM's input files list the number of ships expected to call at each terminal, and the mix of sizes of those ships, which are also specific by terminal. When a ship is created by the model, it first appears at the anchorage point outside of the harbor and runs through a series of checks:

- Is the Port open? (Is the Port closed due to adverse weather condition?)
- Is there enough daylight left to sail to the desired berth? (for large vessels limited to daylight moves)
- Does the channel have sufficient capacity for this vessel to move? (what vessels are in motion right now that this new vessel has to meet?)

If these conditions are all met, the vessel proceeds to its target berth. If not, it waits at anchorage until all of the conditions are met. The model gives preference for outgoing vessels in order to prevent gridlock in the harbor. Once an incoming vessel gets permission to move, it proceeds all the way to its target berth. There are no intermediate queuing positions in the harbor. Similarly, outbound vessels reserve channel capacity all the way to the open sea as soon as they move away from berth.

Note that although the model tracks the usage of pilots and tugs, AECOM assumed that these would not be a constraint to vessel movement over the long term. In other words, although there may be occasional temporary shortages of pilots or tugs, over the long run they will be expanded as needed to serve the Port without any chronic shortages.

In this study, berth capacity was not assumed to cause any delay to incoming vessels (i.e. the berth that ships wanted to reach was always free). This is of course not always true in reality, but the cause and quantity of berth related delay is effectively unknown so that it was not possible to model this source of delay with any degree of confidence. AECOM believes that in reality the amount of vessel delay related to berth congestion is probably quite significant but inclusion of some type of approximate analysis of this here would be more distracting than helpful because of the very low quality of input data.

Vessels are able to "jump the queue" if the criteria allows. For example, a Panamax vessel that arrives at midnight can proceed even if there is a Suezmax vessel waiting at anchorage due to darkness. The model operating rhythm often creates de facto convoy formation (several consecutive vessels travelling in the same direction) but the model does not have any specific convoy rules in place. Vessels move according to their ability and priority regardless of direction of travel.

Each simulation is split up into two seasons: a summer model and winter model. The summer model contains 183 days and no bad weather. The winter model contains 182 days and is closed approximately 10% of the time due to weather (mainly fog). During the bad weather condition, vessels that are docked will continue to be loaded/discharged, vessels that have already left their berth will continue to sail out of the channel or if vessel has entered the channel it will continue to find its berth. Vessels will not be able to start sail if they are ready to leave in a storm. The summer and winter season are then added together to obtain a full year of output data.

4.2 Analysis Results

The base case model rules match those shown in Table 1.2. In addition to these, AECOM analyzed a number of sensitivity cases to determine the potential value of various future rule changes with the larger channel. These included options to allow for Suezmax ships to travel at night as long as they did not meet any other vessels. We also analyzed LNGC movement at night. LNGC vessels cannot meet any other vessels day or night.

Figure 4.1 shows a summary of the base case results. The key metrics shown are total hours of delay, and hours of delay per million BBL of cargo moved. This latter metric takes into account that more cargo is moved with a channel that allows ships to travel at -52' vs -45'.

Figure 4.1. Base Case Results Summary

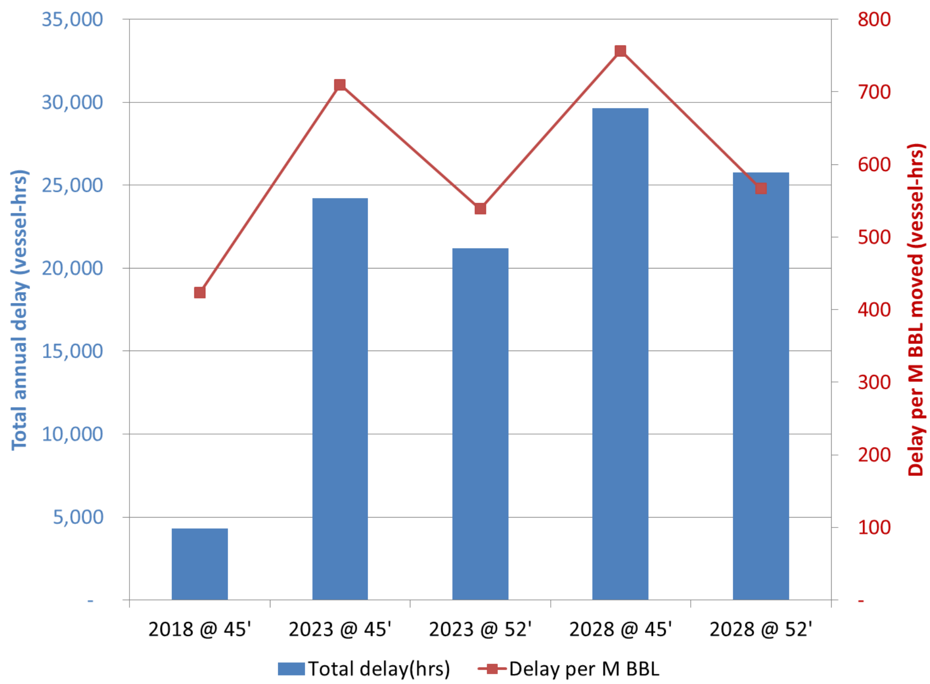
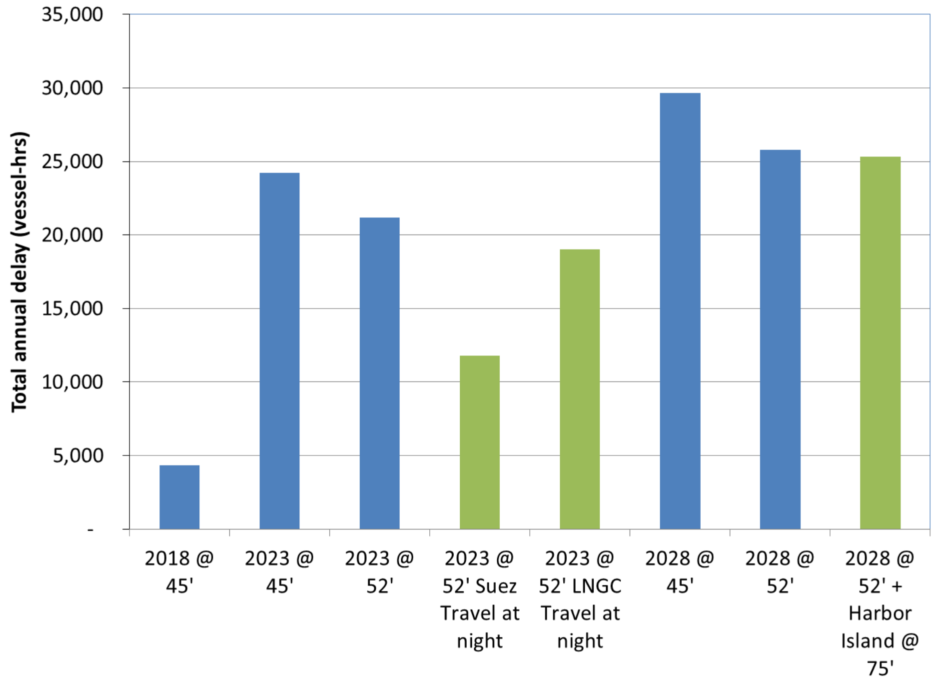


Figure 4.1 shows that channel related delay is expected to increase significantly at the Port, with or without the project, due to the influx of many more large vessels. Even Suezmax vessels cannot move at night in the base case regardless of channel width so delay related to darkness will increase dramatically with or without a larger channel. VLCC and LNGC vessels not only cannot move at night but cannot meet any other ships during daylight so their impact on channel capacity is far greater than other ship classes. Recall from Figure 3.8 that 500 of these high impact vessels are expected to call in 2023 compared with zero in 2018.

Figure 4.1 also shows that the delay per volume of cargo declines even more than the total delay because of the double benefit of the dredging project. It both allows larger vessels to meet, and allows larger vessels to carry more cargo.

Figure 4.2 show the mean delay per vessel for both base and sensitivity cases, the results of which are highlighted in green

Figure 4.2. Sensitivity Case Results Summary



Scenario	Description/Rules	% Change
2023 @ 52’ Suez travel at night	Suez are able to pass each other in the day time and Suez can travel one way at night.	44%
2023 @ 52’ LNGC travel at night	LNGC can travel at night (same rules as daytime)	10%
2028 @ 52’ and Harbor Island @ 75’	VLCC can be fully loaded to 2,120,000 BBL at the Harbor Island Terminal only.	2%

Figure 4.2 shows that the sensitivity case that yields the largest overall benefit is allowing Suezmax (and deep draft Aframax vessels) to travel at night with one-way channel restriction. These ships make up a larger fraction of total vessels calling at the Port than LNGC ships, which is why the benefit of LNGC vessel night travel is not as large, but is still significant in its own right.

The sensitivity case with a super deep channel to Harbor Island that allows for VLCC to completely load at berth has a positive but minor impact on delay. This case assumed that, as indicated in Table 3.2, 100 VLCCs would call per year, but instead of 100 Suezmax and 100 Aframax vessels per year, only 45 of each type would call. The remainder were assumed to be used as shuttle tankers for reverse lightering and no longer needed. A savings of 110 vessel calls per year against a base case of 3,340 annual vessels is only a 3% reduction in total harbor-wide traffic, and the reduction in delay is approximately equal at 2% of the total.

AECOM also used VNM to examine inbound delay for individual berths in order to determine the impact of the new terminal construction and traffic on the Port's existing 2018 customer base. Figure 4.3 shows the results of this analysis, where delay is expressed as a percentage of the current situation.

Figure 4.3. Sensitivity Case Results Summary – Delay to Existing Customers vs 2018

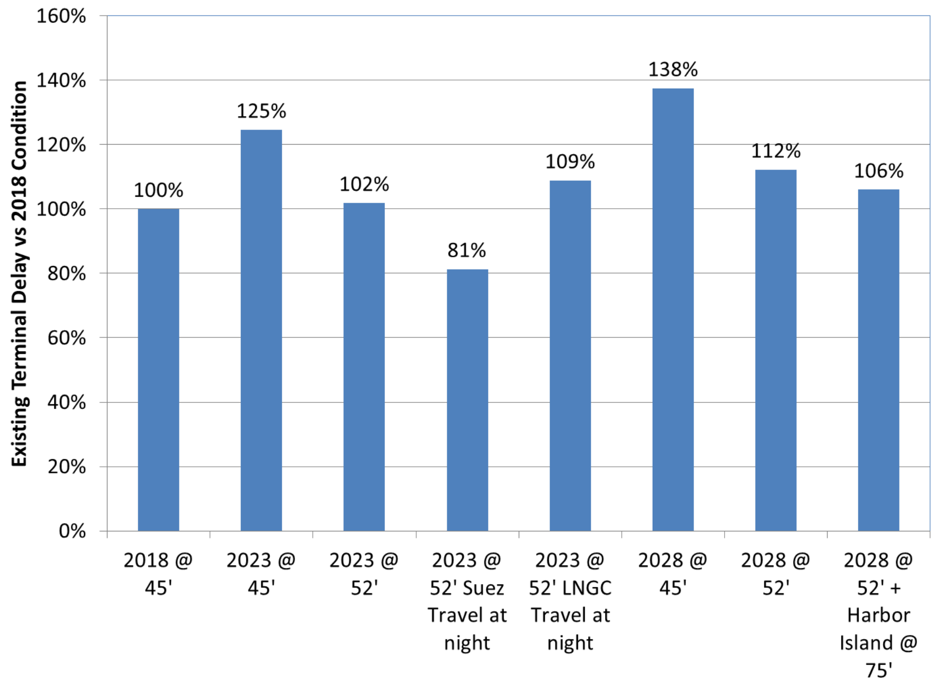


Figure 4.3 shows that if the channel expansion project does not take place, existing Port users will experience a significant amount of delay due to congestion from the addition of new terminals and their large ships. At present, nothing larger than an Aframax can meet a Panamax vessel in Cut A. As Tables 3.2 and 3.3 highlight, the new terminals will have a large fraction of Suezmax or larger ships that cannot meet a Panamax ship in Cut A. After the channel is enlarged, however, two Suezmax ships can meet in Cut A so the new volume of Suezmax vessels no longer impacts existing users and their level of delay in 2023 is effectively unchanged from the present condition.

If Suezmax vessels are allowed to move at night, the delay experienced by existing users will decline substantially vs the current case. Night time delay for Suezmax and heavy Aframax vessels makes up a large part of the current delay experienced by current Port users, so they will benefit along with new users from relaxation of the daytime restriction for large ships.

5. Conclusions

AECOM expects that the next 10 years will bring rapid growth in cargo to the Port of Corpus Christi. Nearly all of this growth will come from crude oil export and LNGC export. The terminals built to handle the crude oil cargo expect to use very large ships to maximize their global supply chain efficiencies. This influx of new large ships will place the Port under a great deal of stress if the channel remains at its present size.

Expanding the channel to allow two Suezmax vessels to meet, and to allow a maximum draft of -52' will mitigate but not eliminate this increase in delay. The primary causes of increased delay are rules that limit operations of large vessels to daytime only. Not only do these rules create delay while waiting for the sun to rise, but they force more traffic to move during a limited number of daylight hours which creates more conflict for meets, especially with VLCC and LNGC vessels that cannot meet any other vessels.

Relaxation of restrictions on night travel for large vessels, even if limited to one-way channel flow, will be very beneficial to the Port. AECOM recommends that these be further investigated and pursued if at all possible.

It is also important to remember that perhaps the greatest benefit to the channel deepening and widening project is the fact that it will allow Port users to carry significantly more cargo per vessel, which will make their entire global supply chain more efficient.