DIRECT ECONOMIC EFFECTS OF LACK OF MAINTENANCE DREDGING OF THE HOUSTON SHIP CHANNEL

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for
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EXECUTIVE SUMMARY

The Houston Ship Channel (HSC) is a federal channel that extends from the Galveston Sea Buoy through Galveston Bay to the Turning Basin in east Houston, Texas. The length of the maintained channel from the Turning Basin to Buoys 1 & 2 is 65 statute miles. The HSC has 115 private and public Coast Guard- regulated facilities, including more than 160 deep-draft berths and a very large number of barge docks and industries that are supported by the deep draft channel. Part of this channel is used by the Port of Galveston and the Port of Texas City. Together, these three entities make up one of the largest port complexes in the nation. Table ES.1 illustrates the importance of these ports.

Table ES.1. 2008 Tonnage for Area Ports

Port	Total Tonnage	National Ranking	Foreign Tonnage	National Ranking	Export Tonnage	National Ranking
Houston	212,207,921	2[a]	146,399,626	1[b]	54,380,670	2
Texas City	52,606,030	14	38,710,435	9	4,783,805	27
Galveston	9,781,368	53	5,581,389	41	3,755,754	28
TOTAL	274,595,319		190,691,450		62,920,229	
% of National	11%		14%		12%	

Source: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center

It is also important to consider the impact of the Houston Ship Channel on the nation's energy supply and petrochemical markets. Houston is considered the energy capital of the world, thanks to the energy infrastructure located directly on the Houston Ship Channel. This waterway is critical for energy markets throughout the nation because it transports raw materials to manufacturing facilities in Houston that in turn produce and distribute refined energy products.

The maintenance of the channel to its authorized width and depth is a federal responsibility that is performed 100 percent by the U.S. Army Corps of Engineers (Corps). The area between the ship channel and berthing facilities is a non-federal responsibility. The HSC has an authorized width and depth established by Congress that varies by channel segment. Although the Corps is responsible for maintaining the HSC at its authorized widths and depths, Congress has not appropriated sufficient funds to do so.

The channel is subject to constant siltation and sloughing, especially during storm events. When the HSC is not maintained to its authorized dimensions, it results in a reduction of

[a] Number 2 for 17 consecutive years
[b] Number 1 for 12 consecutive years

available width and draft. This in turn reduces the amount of cargo a given vessel can carry and stay within channel dimensions. It also imposes certain operational difficulties, which in turn cause financial and operational hardships for shippers, carriers, cargo handlers, and other HSC users. The operating cost of a vessel is not dependent on the amount of cargo it carries (within certain ranges),[c] so a reduction in the amount of cargo carried causes an increase in the average unit cost of transportation for that cargo. For users such as traders, a vessel with reduced cargo is lost business—their opportunities are for a limited time only and cannot be made up with additional vessel calls.

This study involves two types of analyses: (1) analyze the economic effects due to vessel operational and loading limitations associated with channel maintenance at actual depth for actual vessel traffic during the base years, 2008 and 2009 ("Actual"); then (2) analyze the same types of economic effects but assume a loss of 1 ft of draft from actual maintained channel depths, resulting in increased economic impacts ("Actual Minus 1 ft").

The dollar amounts stated in this study account for direct, immediate economic effects. There are other effects that are very real, but are extremely difficult to measure:

- Industrial relocations due to the uncertainty of transportation capacity.
- Diversion of cargo to other ports.
- Loss of ability to compete.
- Effects on national security.
- Increased potential for a collision, oil spill, fire due to an increase in the number of vessel transits.
- Other adverse environmental consequences due to an increase in the number of vessel transits (e.g., air pollution).

There is also the matter of indirect effects that extend into a broader region over time (the multiplier effect). These effects can be calculated using generally accepted models, but require a more extensive scope of work than the one established for Phase 2.

The effects presented in this report should be considered as the lowest possible totals. Calendar Years 2008 and 2009 were selected for this study. Given that 2009 was the trough of the recession and several clients have made improvements to their facilities expecting the authorized channel dimensions to be in place, actual impacts are expected to be significantly greater than what is presented in this document. In other words, an increase in activity will directly affect the magnitude of the effects.

Five categories of effects were identified. Their combined effect on the economics of utilizing the Houston Ship Channel is as shown in Table ES.2.

[c] The conditions analyzed in this study fall within ranges that will not cause vessel operating costs to fluctuate significantly.

Table ES.2. Total Effect of Lack of Channel Maintenance

Year	Actual	Actual Minus 1 Ft
2008	$37,410,605	$281,881,885
2009	$15,288,003	$90,962,018
Total	$52,698,608	$372,843,903

Category 1: Light Loading (Non-Container Vessels)

Category 1 involves light loading of non-container vessels at berths where the maximum sailing draft during the study period was less than the limiting depth for that dock (the lesser of the authorized federal channel or the dock design depth).[d] Within this category, there are two subsets: (1) situations in which the total effect is an increase in shipping cost, and (2) those situations in which the cargo that was left behind cannot be recovered and represents a direct loss of business.

Category 1 contains the greatest financial impact of all the categories. We were able to identify 79 non-container vessel calls that were actually subject to light loading conditions during 2008–2009 (Table ES.3). We were able to identify another 9 vessels that were likely subject to light loading conditions, but for which limited data were available. The value of losses due to actual light loading conditions in 2008–2009 is estimated at $51 million (Table ES.4). The large majority of this amount (96 percent) was due to lost business for select commodities.

When taking actual conditions and assuming a 1-ft additional loss in available draft, we were able to identify 792 non-container vessel calls that would be subjected to light loading conditions during 2008–2009 (see Table ES.3). We were able to identify another 42 vessels that would likely be subject to light loading conditions but for which limited data were available. The value of losses due to light loading under actual conditions plus an additional 1-ft loss of draft are estimated at over $350 million (Table ES.4). The large majority of this amount (88 percent) was due to lost business for select commodities, with losses approximately split between vessel calls to and from HSC berths. .

[d] Container vessel calls are included in Category 5.

Table ES.3. Non-Containerized Vessel Calls Subject to Light Loading

TOTALS	Actual			Minus 1 Ft		
	Affected[e]	No Data[f]	Net	Affected[e]	No Data[f]	Net
2008 Out	11	1	*10*	273	13	*260*
2008 In	30	0	*30*	256	6	*250*
2009 Out	22	6	*16*	187	17	*170*
2009 In	25	2	*23*	118	6	*112*
Totals	*88*	*9*	*79*	*834*	*42*	*792*

Table ES.4. Dollar Effect of Light Loading (Non-Containerized Shipments)

TOTALS	Actual			Minus 1 Ft		
	Effect of increased unit costs	Lost Business	Total Cost	Effect of increased unit costs	Extrapolated Lost Business	Total Cost
2008 Out	$168,823	$0	$168,823	$10,797,357	$117,133,276	$127,930,633
2008 In	$720,246	$35,683,809	$36,404,056	$16,202,915	$131,860,367	$148,063,282
2009 Out	$730,622	$4,544,606	$5,275,228	$7,714,839	$34,809,258	$42,524,097
2009 In	$632,386	$8,774,462	$9,406,848	$6,481,828	$29,518,638	$36,000,466
Total			***$51,254,954***			***$354,518,478***

Table ES.5 lists the docks that were identified as being affected by light loading under actual conditions in 2008 and 2009 and the additional docks that would be affected with a loss of 1 ft of draft.

[e] "Affected" vessels were identified as being affected by draft restrictions under Category 1.
[f] Data regarding the vessel's cargo and itinerary were not available.

Table ES.5. Docks Affected by Draft Restrictions

Actual Conditions		Additional Docks at Actual Minus 1 ft			
Code	Description	Code	Description	Code	Description
EX5	EXXON 5	BC1	BARBOURS CUT 1	C47	CITY DOCK 47
EX6	EXXON 6	BC2	BARBOURS CUT 2	EX5	EXXON 5
C10	CITY DOCK 10	BC3	BARBOURS CUT 3	EX6	EXXON 6
C11	CITY DOCK 11	BC4	BARBOURS CUT 4	GPE	GREENSPORT EAST
C12	CITY DOCK 12	BC5	BARBOURS CUT 5	HCE	HOUSTON CEMENT EAST
C16	CITY DOCK 16	BC6	BARBOURS CUT 6	HF1	HOUSTON FUEL OIL 1
C18	CITY DOCK 18	BLD	BULK PLANT (LOAD)	HF3	HOUSTON FUEL OIL 3
C2	CITY DOCK 2	BP4	BAYPORT CONTAINER 4	KM3	KINDER MORGAN 3
C3	CITY DOCK 3	BP5	BAYPORT CONTAINER 5	KM4	KINDER MORGAN 4
C8	CITY DOCK 8	C14	CITY DOCK 14	KMD	KINDER MORGAN DEEPWATER
C9	CITY DOCK 9	C17	CITY DOCK 17	LB1	LBC1
EX1	EXXON 1	C19	CITY DOCK 19	LB2	LBC2
EX2	EXXON 2	C20	CITY DOCK 20	LB3	LBC3
EX3	EXXON 3	C21	CITY DOCK 21	MG1	MAGELLAN 1
EX4	EXXON 4	C22	CITY DOCK 22	MG2	MAGELLAN 2
HCW	HOUSTON CEMENT WEST	C23	CITY DOCK 23	MNC	MANCHESTER C
KM1	KINDER MORGAN 1	C24	CITY DOCK 24	OD1	ODFJELL 1
SHC	SHELL CRUDE	C25	CITY DOCK 25	OD2	ODFJELL 2
		C26	CITY DOCK 26	OM3	OLD MANCHESTER 3
		C27	CITY DOCK 27	OT5	OILTANKING 5
		C28	CITY DOCK 28	OT6	OILTANKING 6
		C29	CITY DOCK 29	VUL	VULCAN
		C30	CITY DOCK 30	WH1	WOODHOUSE 1
		C31	CITY DOCK 31	WH4	WOODHOUSE 4
		C32	CITY DOCK 32		

Category 2: Partial Discharge at Woodhouse Terminal

Category 2 involves all vessels that had to call at the Woodhouse Terminal for a partial discharge before proceeding to a city dock. Partial discharges are sometimes necessary to reduce the draft of the vessel to available draft at the city docks. The need to conduct business at two terminals instead of one causes an HSC user to incur the cost of a shift of the vessel from one dock to the other (pilot fees and tugboat fees) and extra labor at the Woodhouse Terminal (since it is operated by a different party than the target terminal).

We were able to identify 11 vessel calls that required partial cargo discharges under actual conditions at Woodhouse Terminal during 2008–2009. The value of operational losses due these partial discharges under actual conditions for 2008–2009 is estimated at over a quarter-million dollars.

We were able to identify an additional 21 vessel calls that would require partial cargo discharges at Woodhouse Terminal during 2008–2009 with a 1-ft loss in draft from actual conditions. The value of operational losses due to all partial discharges at this new depth is estimated at over $600,000 for 2008–2009 (Table ES.6).

Table ES.6. Dollar Effect of Partial Discharges at Woodhouse Terminal

	Dollar Effect	
	Actual	Minus 1 ft
2008	$212,892	$493,539
2009	$44,718	$124,107
TOTAL	$257,610	$617,646

Category 3: Maneuvering Stern First

Because of safety concerns, the Houston Pilots imposed a limitation that vessels drafting greater than 28 ft could not use the primary HSC Turning Basin; instead vessels have been required to turn in the secondary Turning Basin located across from City Dock 26 (CD26). This maneuver requires an extra pilot to be on board. Category 3 accounts for the additional expense incurred by vessels with a draft of greater than 28 ft that called and departed from a dock above (upstream from) CD 26.

We were able to identify 192 vessel calls that appeared to require the stern-first maneuver. The additional expenses due to these maneuvers under actual conditions for 2008–2009 are estimated at almost a half-million dollars.

We were able to identify an additional 58 vessel calls that would require partial cargo discharges at Woodhouse Terminal during 2008–2009 with a 1-ft loss in draft from actual conditions. The additional expenses due to all such maneuvers at this new depth are estimated at over $600,000 for 2008–2009 (Table ES.7).

Table ES.7. Dollar Effect of Maneuvering Stern First

	Total Extra Expense	
	Actual	Minus 1 ft
2008	$306,771	$415,272
2009	$163,352	$206,006
TOTAL	$470,123	$621,278

Category 4: Daylight Restrictions

Under normal conditions, the Houston Ship Channel would be maintained at authorized depth plus 2 ft. The additional 2 ft were available because the Corps would typically ask the dredger to excavate deeper than the authorized depth in order to reduce the maintenance cost for the channel. When this additional 2 ft (commonly referred to as "advanced maintenance") is not available, vessel operations at drafts near authorized channel depths are restricted. The Houston Pilots established a requirement that vessels drafting greater than 39 ft and transiting the ship channel above (upstream) from the Shell Oil docks could only move during daylight hours due to the increased risks of allusions or groundings while moving these vessels. Category 4 accounts for vessels that appear to have been subject to a daylight only restriction by the pilots—vessels drafting more than 39 ft and transiting the restricted area.

When restricted to daylight hours, a certain number of vessels will be required to pay vessel operating costs and dockage (for outbound vessels) while they sit idle. We were able to identify 131 vessel calls that appeared to be subject to the daylight restriction. The additional expenses incurred by these vessels under actual conditions in 2008–2009 are estimated at over $700,000.

We were able to identify an additional 104 vessel calls that would be subject to the daylight restriction during 2008–2009 with a 1-ft loss in draft from actual conditions. The additional expenses due to all such maneuvers at this new depth are estimated at $1.2 million for 2008–2009 (Table ES.8).

Table ES.8. Dollar Effect of Daylight Restrictions

	Dollar Effect	
	Actual	Minus 1 ft
2008	$318,062	$611,159
2009	$397,857	$592,342
TOTAL	$715,919	$1,203,501

Category 5: Light Loading Container Shipments

Information provided by container lines suggests that the actual channel depth was generally maintained at the designed depth of 40 ft for this period and therefore they have been able to operate as planned to date. Representatives of these lines were careful to point out that container ships are continually increasing in size (width and depth); the current authorized dimensions of the HSC prevent them from maximizing the opportunity of their vessel capacity at the Port of Houston. The lines have indicated that it is desirable to have a 45-ft channel draft at Barbours Cut Terminal and Bayport Terminal. A lack of maintenance dredging compounds the effects of an already inefficient channel design.

Inbound shipments would not ordinarily be affected by a slight reduction in channel depth because most inbound containers contain lower-density cargos, and most actual container weights are less than maximum allowable container weights. This reduces the tonnage of loaded inbound vessels and reduces the required draft to less than current channel depth. However, outbound shipments tend to consist of higher-density cargoes where the container's maximum weight is reached before it is filled. Thus, any reduction in channel depth for outbound containerized cargoes could have a serious effect on container line revenues. This category analyzes outbound container shipments and evaluates the potential effect of a loss of 1 ft of channel depth from actual conditions.

We were able to identify 134 outbound container vessel calls during 2008–2009 for which a 1-ft loss in draft from actual conditions would limit the amount of cargo carried. The estimated loss of revenue to container ship operators for this category totals almost $16 million.

Table ES.9. Dollar Effect of Light Loading (Containerized)

	Dollar Effect
2008 Minus 1 ft	$4,368,000
2009 Minus 1 ft	$11,515,000

Summary and Conclusions

The large majority of estimated economic impacts of HSC maintenance are due to "light loading" of vessels carrying non-containerized cargoes, and most of these losses are associated with lost business opportunities, followed by increases in unit costs of transport. Under actual conditions, estimated HSC losses totaled over $52 million in 2008-2009. There were no estimated losses due to light loading for containerized cargoes under actual conditions based on information provided by container lines. Table ES.10 summarizes estimated effects for the categories of impacts included in the analysis, along with total estimated losses, under actual conditions for 2008-2009.

Table ES.10. Dollar Effect under Actual Conditions, 2008-2009

Impact Category	2008-2009 Estimated Economic Effects, Actual Conditions
Category 1: Lost business due to light loading of non-containerized vessels	$49,002,877
Category 1: Unit cost increases due to light loading of non-containerized vessels	$2,252,077
Category 2: Partial cargo discharges at multiple locations	$257,610
Category 3: Stern-first maneuvering at secondary Turning Basin	$470,123
Category 4: Daylight-restricted vessel operations	$715,919
Category 5: Light loading of containerized vessels	$0
Total	$52,698,608

Table ES.11 lists the estimated economic effects assuming an additional loss of 1 ft of available draft from actual conditions in 2008-2009. HSC losses would total nearly $373 million in 2008-2009. As with estimates for actual conditions, lost business opportunities due to light loading of non-containerized vessels accounts for a high percentage of impacts. The proportion of unit cost increases due to light loading of these vessels compared with losses under actual conditions increased from around 4 percent of total impacts to around 11 percent. With a 1-ft loss in available draft, containerized trade losses would be nearly $16 million over the time period, also around 4 percent of total estimated impacts.

Table ES.11. Dollar Effect of HSC Maintenance with Additional Loss of 1 ft Available Draft from Actual Conditions, 2008-2009

Impact Category	2008-2009 Estimated Economic Effects, Actual Conditions Minus 1 ft Available Draft
Category 1: Lost business due to light loading of non-containerized vessels	$313,321,539
Category 1: Unit cost increases due to light loading of non-containerized vessels	$41,196,939
Category 2: Partial cargo discharges at multiple locations	$617,646
Category 3: Stern-first maneuvering at secondary Turning Basin	$621,278
Category 4: Daylight-restricted vessel operations	$1,203,501
Category 5: Light loading of containerized vessels	$15,883,000
Total	$372,843,903

Since estimates were generated for 2008-2009—years in which maritime trade was significantly reduced from previous years when economic growth was occurring—the impacts of such efficiencies may be potentially greater than estimated for this study with an economic rebound.

The over seven-fold increase in estimated economic losses with a loss of 1 ft of available draft in the Houston Ship Channel suggests the significance of HSC maintenance to HSC users, the Port of Houston, and Southeast Texas. The sharp increase in economic losses with a loss of only 1 ft of available draft suggests that many vessels calling to and from berths along the HSC are operating to the maximum degree allowed by current channel depth.

CHAPTER 1: BACKGROUND AND PROJECT APPROACH

This report is the culmination of a two-phased project to identify and quantify the direct economic impacts that result from a lack of maintenance dredging of the Houston Ship Channel. The impacts were first evaluated for 2008–2009 within the framework of the conditions that existed at the time. Subsequently, an evaluation was performed for the effects of losing one more foot of available draft from actual conditions.

The Houston Ship Channel (HSC) is a federal channel that extends from the Galveston Sea Buoy through Galveston Bay to the Turning Basin in east Houston, Texas. The length of the maintained channel from the Turning Basin to Buoys 1 & 2 is 65 statute miles. The HSC has 115 private and public Coast Guard- regulated facilities, including more than 160 deep-draft berths and a very large number of barge docks and industries that are supported by the deep draft channel. Part of this channel is used by the Port of Galveston and the Port of Texas City. Together, these three entities make up one of the largest port complexes in the nation. Table 1 illustrates the importance of these ports.

Table 1. 2008 Tonnage for Area Ports

Port	Total Tonnage	National Ranking	Foreign Tonnage	National Ranking	Export Tonnage	National Ranking
Houston	212,207,921	2[g]	146,399,626	1[h]	54,380,670	2
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Source: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center

It is also important to consider the impact of the Houston Ship Channel on the nation's energy supply and petrochemical markets. Houston is considered the energy capital of the world, thanks to the energy infrastructure located directly on the Houston Ship Channel. This waterway is critical for energy markets throughout the nation because it transports raw materials to manufacturing facilities in Houston that, in turn produce and distribute refined energy products.

The maintenance of the channel to its authorized width and depth is a federal responsibility which is performed 100 percent by the U.S. Army Corps of Engineers (Corps). The area between the ship channel and berthing facilities is a non-federal responsibility. The HSC has an

[g] Number 2 for 17 consecutive years
[h] Number 1 for 12 consecutive years

authorized width and depth established by Congress that varies by channel segment. Although the Corps is responsible for maintaining the HSC at its authorized widths and depths, Congress has not appropriated sufficient funds to do so.

THE IMPORTANCE OF THE HOUSTON SHIP CHANNEL

In addition to the statistics mentioned on the previous page…

- The Port of Houston provides $118 billion in annual economic benefit to the state of Texas, including more than 785,000 jobs.
- Customs revenue collected by the federal government from Port of Houston cargo exceeds $768 million per year (2007).
- Approximately $171.1 million in harbor maintenance tax is collected annually from the Houston Region (Ports of Houston, Texas City, Galveston, and Freeport – 2007 estimate). This is more than is annually requested to be returned back to maintain these ports.
- The Port of Houston is ranked:
    - 1st in U.S. in foreign tonnage (12 consecutive years);
    - 1st in U.S. imports (17 consecutive years);
    - 2nd in total U.S. tonnage (17 consecutive years);
    - 2nd in U.S. exports;
    - 7th largest container port in the U.S.;
    - 1st in steel imports in the Gulf Coast; and,
    - 1st in containers in the Gulf Coast.

- The Port of Houston is ranked as the largest importer and exporter of petroleum and petroleum products in the United States.
- The Port is also home to the second largest petrochemical complex in the world.
- Currently, the country's largest refinery, with a refining capacity of 567,000 barrels a day, is located on the channel.
- This refinery and the other refineries in and around the Port of Houston make Houston the largest refinery center in the United States.
- Facilities along the HSC comprise 56% of the nation's oil pipeline capacity and 73% of the nation's natural gas pipeline capacity.
- Houston Ship Channel industries account for nearly 40% of the nation's petrochemical manufacturing capacity, including:
    - 37% of U.S. polyethylene production
    - 37% of U.S. polyvinyl chloride production; and
    - 53% of U.S. polypropylene production.

Source: Port of Houston Authority

The channel is subject to constant siltation and erosion, especially during storm events. When the HSC is not maintained to its authorized dimensions, it results in a reduction of available width and draft. This in turn reduces the amount of cargo a given vessel can carry and stay within channel dimensions; it also imposes certain operational difficulties, which in turn cause financial and operational hardships for shippers, carriers, cargo handlers, and other HSC users. The operating cost of a vessel is not dependent on the amount of cargo it carries (within certain ranges)[i], so a reduction in the amount of cargo carried causes an increase in the average unit cost of transportation for that cargo. For users such as commodity traders, a vessel with reduced cargo is lost business—their opportunities are for a limited time only and cannot be made up with additional vessel calls.

The methodology for this study involves two analyses: (1) analyze the economic effects due to vessel operational and loading limitations associated with channel maintenance at actual depth for actual vessel traffic during the base years, 2008 and 2009 ("Actual"); then (2) analyze the same types of economic effects but assume a loss of one foot of draft from actual maintained channel depths, resulting in increased economic impacts ("Actual Minus 1 ft").

Phase 1

The goal of the Phase 1 effort was to establish a methodology for identifying and quantifying the economic impacts of failure to adequately maintain the Houston Ship Channel. Phase 2 employed the methodology developed during Phase 1 to estimate the economic impact values.

The specific tasks called for in Phase 1 included:

1. Study and understand the HSC situation.
    a. Review draft restrictions in the channel for the previous two years.
    b. Determine who might be affected, how they might be affected, and how it might be measured.
    c. Interview stakeholders and receive their input on statistics and data sources.

2. Define data to be collected and the best sources.

3. Develop scope for next phase of work.
    a. Define the required and desired characteristics of the model or methodology to be used to identify and quantify impacts.

[i] The conditions analyzed in this study fall within the range that will not cause vessel operating costs to fluctuate significantly.

b. Perform a high-level analysis of available data sets to determine magnitude of potential impacts and level of effort required to develop statistics and dollar amounts.

4. Concurrently with the Tasks 1 through 3, evaluate prior efforts to accomplish the same goal in other ports around the country.

TTI interviewed 29 businesses and government agencies that are actively involved in the use of the Houston Ship Channel. As part of each interview, the TTI researcher discussed the reason for this study, potential impacts of draft or width restrictions, and potential data sources that would enable TTI to quantify the effects. The focus was strictly on the impacts of not maintaining the authorized depth, as opposed to the impacts of not having a deeper authorized channel. The organizations that were interviewed are listed in Table 2.

Table 2. Interviewees

American Eagle Tankers	Maersk
American Shipping and Chartering	Oiltanking
Bay-Houston Towing	PHA Turning Basin Terminals Staff
Biehl & Co.	Rickmers Linie
BP Refinery[j]	Salzgitter Mannesmann International
CMA CGM	Schroder Marine
Cooper T. Smith	Skaugen Petrotrans
ExxonMobil, Baytown	Teekay
Greater Houston Port Bureau	Trafigura
Hanson Mueller	US Coast Guard Vessel Traffic System
Houston Fuel Oil	US Army Corps of Engineers, Institute for Water Resources
Houston Pilots	Vopak
ITC	Valero
Kinder Morgan	West Gulf Maritime Association
Lockwood Logistics	

Despite repeated attempts, we were not able to arrange interviews with the businesses listed in Table 3.

[j] BP is not located on the Houston Ship Channel. However, because of the difficulty encountered in getting refineries to speak with TTI researchers, BP was interviewed to obtain an understanding of the refinery-related issues.

Table 3. Unsuccessful Interview Attempts

Cargill
Chevron
Shell Refinery
Glencore/ST Shipping
Gulf Stream Marine
Hyundai Marine
Jacob Stern & Sons
PMI (Pemex)
Westport Petroleum

The scope of work called for 15 interviews, but due to scheduling efficiencies, several telephone interviews, and the cooperation of the interviewees, it was possible to conduct more interviews than were initially planned.

In an attempt to avoid "reinventing the wheel," we sent e-mails to all members of the American Association of Port Authorities Harbor, Navigation & Environment Committee. In that e-mail, we asked if their port authority had ever conducted studies to quantify the effects of navigation restrictions. None of the members responded that they had. A few responded that they had conducted channel deepening studies with the Corps, but not the type of study requested. Port Manatee provided information regarding how they valued lost liner opportunities.

We also performed an extensive literature review. As a result of that review, we obtained copies of several documents and investigated their usefulness to the project. Among them were:

- *Columbia River Channel Improvement Project, Final Supplemental Integrated Feasibility Report and Environmental Impact Statement.*
- *Corpus Christi Ship Channel, Texas Channel Improvement Project, Final Feasibility Report and Final Environmental Impact Statement.*
- *Great Lakes St. Lawrence Seaway Study (2007).*
- *Lake Charles Dredge Material Management Plan Economic Report (2009).*
- *Port of Redwood City Dredging Issues and Impacts.*
- *Proposed Port Freeport Channel Widening, Draft Environmental Impact Statement.*
- *Providence River and Harbor Maintenance Dredging Project, Final Environmental Impact Statement Brazos Island Harbor Channel Improvement Project, Feasibility Study.*
- *Texas City Channel Deepening Project, General Reevaluation Report and Environmental Assessment.*

Unfortunately, these studies did not produce any information or methodologies that would be useful for the present study.

We also reviewed the Corps' Channel Prioritization Tool (CPT). An important premise of the approach used in the CPT is that the extent to which maintained depths are utilized by transiting vessels is a useful metric when attempting to prioritize navigation projects across the Corps' navigation portfolio. While tonnage totals offer an expedient way for Corps decision makers to evaluate the relative significance of navigation projects, the developers of CPT claim that incorporation of additional data such as draft and cargo value provides improved justification for maintenance dredging investments.

The CPT assists decision makers with extracting and processing pertinent data subsets from the Waterborne Commerce Statistic Center's (WCSC) confidential database. The decision maker is able to visualize the distribution of tonnage transiting a given reach across the range of channel depths, not just the single cumulative tonnage amount. The CPT places a value on the cargo by utilizing a separate dataset maintained and published by the Foreign Trade Division of the U.S. Census Bureau (2009) and cross referencing it with the WCSC data.

While the value of cargo may be useful for limited facets of the present study, it does not indicate the *cost* incurred when these shipments are "disrupted" or made less efficient. Given this fact, CPT is not an adequate tool for the overall objectives of this study.

Phase 2

The work performed in Phase 2 accounts for the direct, immediate effects of a channel that is not maintained at its authorized depth. There are other effects which are very real, but are extremely difficult to measure:

- Industrial relocations due to the uncertainty of transportation capacity.
- Diversion of cargo to other ports.
- Loss of ability to compete.
- Effects on national security.
- Increased possibilities for a collision, oil spill, or fire due to an increase in the number of vessel transits.
- Other adverse environmental consequences due to an increase in the number of vessel transits (e.g., air pollution).

There is also the matter of indirect effects that reach out into a broader region over time (the "multiplier effect"). These effects can be calculated using generally accepted models, but require much more data and time than what was envisioned for Phase 2.

The effects presented in this report should be considered as the lowest possible totals. Calendar Years 2008 and 2009 were selected for this study. Given that 2009 was the trough of the recession and several clients have made improvements to their facilities expecting the authorized channel dimensions to be in place, actual impacts are expected to be significantly

greater than what is presented in this document. In other words, an increase in activity will directly affect the magnitude of the effects.

There were several data collection and "clean-up" tasks that were necessary for the Phase 2 analysis. Among them were:

1. Linking the data files obtained from the Houston Pilots, the Port of Houston Authority[k], and the Greater Houston Port Bureau, and resolving discrepancies.
2. Acquiring the tons per centimeter factor[l] for all vessels experiencing a reduction in cargo-carrying capacity.
3. Characterizing the cargo of the vessels for which there was no information in the files regarding the cargo on board and its origin or destination.
4. Determining last/next port of call for vessels included in Category 1 (described below).
5. Acquiring commodity pricing data for users that were identified as losing business within Category 1.
6. Acquiring vessel operating costs and service speeds.
7. Verifying authorized channel depths and design drafts for piers included in the data files—both public and private.

Initially, five categories were identified. The last category identified in Phase 1 involved lightering operations. After collecting data and speaking with the person in charge of one of the Houston lightering operations, it was determined that this category was not a valid category. It was subsequently replaced with the Category 5 described below. The details for each selected category are provided in subsequent chapters.

Each of these categories requires the extraction of data from one or more of the following files: (1) Greater Houston Port Bureau vessel data, (2) Houston Pilots vessel calls, and (3) Journal of Commerce's PIERS data set. This analysis uses both the 2008 and 2009 data sets. With the assistance of the Port of Houston Authority ("Port"), we acquired these data sets and merged them in such a fashion that each vessel call could be appropriately analyzed. The categories can be summarized as follows.

Category 1: Light Loading (Non-Container Vessels)

Category 1 involves non-container vessel calls at berths where the maximum sailing draft during the study period was less than the limiting depth for that dock (the lesser of the authorized federal channel or the dock design depth).[m] Within this category, there are two subsets: (1) situations in which the total effect is an increase in shipping cost, and (2) those situations in

[k] The Port of Houston Authority made its PIERS data files available for this analysis. (PIERS stands for Port Import Export Reporting Service—a service of the Journal of Commerce.)

[l] The tons per centimeter factor states how many tons of cargo must be removed from a vessel to cause a change of one cm in draft

[m] Container vessels are included in Category 5.

which the cargo that was left behind cannot be recovered and represents a direct loss of business. Category 1 contains the greatest financial impact of all the categories.

Category 2: Partial Discharge at Woodhouse Terminal

Category 2 involves all vessels that had to call at the Woodhouse Terminal for a partial discharge before proceeding to a city dock. Partial discharges are sometimes necessary to reduce the draft of the vessel to available draft at the city docks. The need to conduct business at two terminals instead of one causes a user to incur the cost of a shift of the vessel from one dock to the other (pilot fees and tugboat fees) and extra labor at the Woodhouse Terminal (since it is operated by a different party than the target terminal).

Category 3: Maneuvering Stern First

Because of safety concerns, the Houston Pilots imposed a limitation that vessels drafting greater than 28 ft could not use the primary Turning Basin; instead vessels have been required to turn in the secondary Turning Basin located across from City Dock 26 (CD 26). This maneuver requires an extra pilot to be on board. Category 3 accounts for the additional expense incurred by vessels with a draft of greater than 28 ft that called and departed from a dock above (upstream from) CD 26.

Category 4: Daylight Restrictions

Under normal conditions, the Houston Ship Channel would be maintained at a depth of 40 ft plus 2 ft. The additional two feet were available because the Corps would typically ask the dredger to excavate deeper than the authorized depth in order to reduce the maintenance cost for the channel. When this additional 2 feet (commonly referred to as "advanced maintenance") is not available, vessel drafts must be restricted. The pilots established a requirement that vessels drafting great than 39 ft and transiting the ship channel above (upstream) from the Shell Oil docks could only move during daylight hours due to the increased risks of allusions or groundings while moving these vessels. Category 4 accounts for vessels that appear to have been subject to daylight-only maneuvering restriction by the pilots—vessels drafting more than 39 ft and transiting in the restricted area.

Category 5: Light Loading Container Shipments

Information provided by container lines suggests that the actual channel depth was generally maintained at the designed depth of 40 ft for this period and therefore they have been able to operate as planned to date. Inbound shipments would not ordinarily be affected by a slight reduction in channel depth because most inbound containers contain lower-density cargos, and most actual container weights are less than the maximum allowable container weights. This reduces the tonnage of loaded inbound vessels and reduces the required draft to less than current channel depth. However, outbound shipments tend to consist of higher density

cargoes where the container's maximum weight is reached before it is filled. Thus, any reduction in channel depth for outbound containerized cargoes could have a serious effect on container line revenues. This category analyzes outbound container shipments and evaluates the potential effect of a loss of 1 ft of channel depth from actual conditions.

CATEGORY 1: LIGHT LOADING

Selection and Data Acquisition

Category 1 involves non-container vessel calls at berths where the maximum sailing draft during the study period was less than the limiting depth for that dock (the lesser of the authorized federal channel or the dock design depth).[n] Within this category, there are two subsets: (1) situations in which the total effect is an increase in shipping cost, and (2) those situations in which the cargo that was left behind cannot be recovered and represents a direct loss of business.

The foundation of this analysis is the knowledge of authorized channel depths at berth locations and the design draft of the berths. An analyst must be able to determine what actually limits the draft of a vessel—the channel or the depth at the dock. We reviewed information supplied by the Port of Houston Authority and the Houston Pilots. Where there was reason to doubt the validity of the information—or when the information was not available—we contacted the terminal directly. The dock codes used by the Houston Pilots, the limiting design draft, whether the docks appeared to experience a draft restriction, and the maximum sailing draft for each dock are shown in Appendix A. The column in Appendix A labeled "Ignore Flag" indicates which locations were dropped from further consideration.

Because of the extremely large size of the data sets, several key assumptions were used to limit the initial data set:

- Only vessels with a design maximum draft of 28 ft or greater were selected. The shallowest reach of the channel was 28 ft at the time this study began.
- Since all reaches of the channel and almost every dock along the channel has a design depth greater than 28 ft, only vessels that actually drafted more than 28 ft were selected.
- The pilot data show that at certain dock locations, vessels have been sailing at the limiting design draft. These sites were eliminated from further analysis of the effects under actual conditions.
- The design depth for many docks is less than the authorized channel depth; these sites were eliminated. Several of these facilities have recently dredged their berthing areas to a greater depth; therefore, future studies would show impacts to their facilities that this study does not include.
- Each dock that appeared to have a maximum sailing draft less than the limiting design draft (lesser of authorized channel depth or design depth for dock) was compared to docks upstream (above) the dock in question. If the upstream sites exhibited deeper

[n] Container vessels are included in Category 5.

maximum sailing drafts than the dock in question, the dock in question was eliminated from further consideration.

Movements between a channel dock location and Bolivar Roads were excluded, as were movements originating or terminating in Texas City or Galveston. The distance between HSC facilities and these points is so small that they were considered as shifts rather than vessel arrivals or departures.

- The limiting draft for a given location is presumed to be the lesser of the channel project depth or the pier project design depth.
- When calculating lost tonnage, all vessels within 1 ft of the maximum sailing draft for the particular dock were included. The assumption is that these vessels sailed with the maximum draft available to them and would have added the additional draft had it been available.

For the "minus 1 ft" scenario, the authorized channel depth was reduced by 1 ft and the analysis was repeated. Eighty-nine vessel calls were identified has having been affected by draft restrictions in 2008–2009. A total of 834 vessels were identified as affected with a loss of 1 ft of draft (this includes all vessels affected under actual conditions). Seventy-six of the 836 selected vessel calls for 2008–2009 in the pilot log did not have any corresponding entries in the PIERS dataset. We contacted vessel agents in an attempt to obtain the needed information. Information for 34 vessel calls was provided by the agents. The remainder (42) amount to 5 percent of the total selected vessel calls. These calls were included in the analysis by linear extrapolation of the results for vessels with complete data.

Once the vessels were identified as being affected by draft restrictions, we added information to enable the analysis. The vessel's tons per centimeter (TPC) factor and vessel service speed were obtained from IHS Fairplay/Lloyd's Register. This information was not available for all vessels. After consultation with the Corps' Institute for Water Resources, we established a table of drafts with 1 ft increments. To calculate the missing TPC factor and service speeds, we selected all vessels listed in Lloyd's Register with a maximum draft within the same 1 ft range as the vessel's maximum draft, and used the average of their TPC factors and speed (e.g., a general cargo ship with a maximum draft of 36.4 ft would be assigned the average of all TPC factors or operating speeds for general cargo ships in the 36 to 37 ft draft range). Additionally, the commodity category accounting for the greatest tonnage on board and its port of origin/destination were obtained from PIERS data or from the steamship agents that handled the vessel.

Data files that were initially provided to us included each vessel's maximum draft, gross registered tonnage, and deadweight tonnage. However, we noted significant discrepancies and errors in these data; therefore, we verified each selected vessel's pertinent design information by consulting IHS Fairplay/Lloyd's Register.

For inbound vessels, we identified the last port of call and for outbound vessels we identified the next port of call based on a combination of port call information published by Lloyd's Register[o] and data contained in the PIERS data sets. If indicated, the limiting draft for a vessel call was reduced to the next/last port's maximum draft. While the "actual limiting port" may be earlier than the last port or later than the next port, the complexity of many vessel routes is such that it is not possible to determine which port—if any—limited a vessel's cargo carrying capacity. However, one can be certain that the next/last port has a direct effect on the vessel's load, and therefore, their limiting draft was factored into the analysis.

To determine the limiting draft for the vessel, we identified the lesser of the authorized channel depth or the design depth for applicable docks along the HSC. Then we acquired the limiting depth for the next port of call (outbound) or last port of call (inbound). The actual limiting draft was set at the least of the HSC authorized channel depth, the limiting depth of the next/last port of call, and the design depth of applicable docks along the HSC. The limiting depths for each port were identified by consulting port websites and Lloyd's Register's Ports and Terminals Guide. The Panama Canal was treated as the next/last port of call when the vessel's route utilized it. Once the limiting draft was established, we calculated the tonnage the vessel should have been able to carry absent any siltation in the channel.

In this analysis, the effect of an increase in unit costs is levied against all cargo on board the vessel. Because many vessels calling at the Port of Houston do not carry cargo only for Houston, it was not possible to determine the total amount of cargo on board specifically for the Port of Houston call. Therefore, we used the vessel's sailing draft as reported by the Houston Pilots, the vessel's deadweight tonnage capacity (adjusted for water, bunkers, crew, etc.), and the TPC factor to determine the approximate tonnage on board the vessel at the time of the arrival/departure.

Based on the Phase 1 interviews, TTI identified cargoes that are typically handled by commodity traders—primarily oil and steel. Oil and steel traders typically use third parties to store and handle their cargo. The other cargoes most likely to be "fully loaded" cargoes and therefore subject to a loss of business are primarily cement, aggregates, grain, and scrap metal. The appropriate classification of each shipment was accomplished by consulting importer, exporter, and vessel agency records in the PIERS data for the selected shipments. It is assumed that additional commodity quantities were available for shipment or delivery and the tonnage capacity sacrificed by vessels in this category was deemed to be lost business.

For the remaining non-containerized shipments, the type of commodity was not relevant. We simply calculated the increased unit cost for the affected shipments. Table 4 contains the number of vessel calls affected by draft restrictions under Category 1.

[o] IHS Fairplay's web site www.sea-web.com provides the AIS (Automatic Identification System) records by vessel. These records are not complete, but they aided substantially in determining each vessel's itinerary.

Table 4. Non-Containerized Vessel Calls Subject to Light Loading

TOTALS	Actual			Minus 1 Ft		
	Affected[p]	No Data[q]	Net	Affected[p]	No Data[q]	Net
2008 Out	11	1	*10*	273	13	*260*
2008 In	30	0	*30*	256	6	*250*
2009 Out	22	6	*16*	187	17	*170*
2009 In	25	2	*23*	118	6	*112*
Totals	*88*	*9*	*79*	*834*	*42*	*792*

Breakdown by Subcategory

	Actual			Minus 1 Ft		
	Unit cost increases only	Unit cost increase & lost business	Net	Unit cost increases only	Unit cost increase & lost business	Net
2008 Out	0	10	*10*	92	168	*260*
2008 In	19	11	*30*	81	169	*250*
2009 Out	4	12	*16*	39	131	*170*
2009 In	3	20	*23*	18	94	*112*
Totals			*79*			*792*

Does not include lightering

Valuation

The valuation of the effect of the loss of draft was performed as follows:

- The vessel operating costs were calculated for each vessel.
  - The hourly at sea and in port costs for each vessel class were obtained from the Corps' Institute for Water Resources. Using the vessel's service speed and the distance between Houston and the port of origin/destination for the primary commodity being transported, the length of the voyage in hours was calculated. This results in a conservative estimate of the time in transit since a vessel will have to travel at less than service speed under certain weather conditions and in many cases there were intervening port calls between the origin/destination port and Houston; it was assumed those calls would have been made regardless of HSC conditions. Therefore, only the costs incurred to cover the distance between the two ports was considered.
- The unit transportation cost was calculated for each vessel.

[p] "Affected" vessels were identified as being affected by draft restrictions under Category 1.
[q] Data regarding the vessel's cargo and itinerary were not available.

    - The vessel operating cost was divided by the estimated total cargo actually carried. This value is the actual unit cost.
    - The vessel operating cost was divided by the total cargo that could be carried if the vessel were loaded to the capacity allowed by the limiting design draft. This unit cost is the unrestricted unit cost. It will always be less than or equal to the actual unit cost.
    - The difference between the actual unit cost and the unrestricted unit cost is the unit cost increase due to light loading.
- The effect of the loss of draft is equal to the unit cost increase due to light loading multiplied times the estimated tonnage actually transported by the selected vessels.

For "lost business" shipments:

- We calculated the difference between what the vessel should have been able to transport at the appropriate limiting design draft and what it actually transported. This difference was classified as "lost tonnage" resulting in lost business.
- It was determined that 14 commodities were involved at the 4-digit PIERS code level. Four of these commodities accounted for 84 percent of the selected vessel calls and 89 percent of the lost tonnage to be valued. The values of these commodities per metric ton are displayed in Table 5. These values are the calendar year average values. A detailed description of how these prices were determined is provided in Appendix B.

Table 5. Commodity Prices for Category 1

Commodity	2008$/MT	2009$/MT
Grains & Flour Prods	$306.01	$209.75
Petroleum/Crude & Fuel Oil	$698.61	$441.69
Cement & Clinkers	$103.00	$101.59
Limestone Chips	$8.24	$8.68

Given that the remaining 11 percent was spread across 10 commodities, some of which have almost no publicly available market price data, it was decided to simply extrapolate the 89 percent to the 100 percent level. In other words, the total cost for x tons was divided by 0.89 to obtain the overall cost of the draft restriction.

The two primary effects to consider are: (1) the increased unit costs for shipments that are less than the vessel would carry at the limiting design draft and (2) the value of lost cargo. Table 6 shows the economic penalty incurred due to light loading. The table displays the totals and then apportions the totals into two components: (1) vessels with lost business and (2) vessels that experienced an increase in freight costs, but did not necessarily lose business.

Table 6. Dollar Effect of Light Loading (Non-Containerized Shipments)

TOTALS	Actual			Minus 1 Ft		
	Effect of increased unit costs	Lost Business	Total Cost	Effect of increased unit costs	Extrapolated Lost Business	Total Cost
2008 Out	$168,823	$0	$168,823	$10,797,357	$117,133,276	$127,930,633
2008 In	$720,246	$35,683,809	$36,404,056	$16,202,915	$131,860,367	$148,063,282
2009 Out	$730,622	$4,544,606	$5,275,228	$7,714,839	$34,809,258	$42,524,097
2009 In	$632,386	$8,774,462	$9,406,848	$6,481,828	$29,518,638	$36,000,466
Total			***$51,254,954***			***$354,518,478***
1a: Vessels with Lost Business						
2008 Out	$0	$0	$0	$1,930,836	$117,133,276	$119,064,112
2008 In	$122,690	$35,683,809	$35,806,499	$1,378,635	$131,860,367	$133,239,002
2009 Out	$82,931	$4,544,606	$4,627,537	$1,049,426	$34,809,258	$35,858,684
2009 In	$20,256	$8,774,462	$8,794,718	$501,021	$29,518,638	$30,019,659
Total			*$49,228,754*			*$318,181,457*
1b: Vessels with Increased Unit Costs Only						
2008 Out	$168,823	$0	$168,823	$8,866,521	$0	$8,866,521
2008 In	$597,556	$0	$597,556	$14,824,280	$0	$14,824,280
2009 Out	$647,691	$0	$647,691	$6,665,414	$0	$6,665,414
2009 In	$612,130	$0	$612,130	$5,980,808	$0	$5,980,808
Total			*$2,026,201*			*$36,337,023*

A number of vessel calls were included in more than one category—in other words, they suffered multiple penalties in the analysis. Table 7 shows the number or vessels included in the Category 1 analysis that were also included in other categories.

Table 7. Vessels Calls Affected by More than One Category

	2008	2009
Affected by Category 2	12	2
Affected by Category 3	36	9
Affected by Category 4	146	102
Affected by 2 and 3	9	2
Affected by 3 and 4	1	0
TOTALS	204	115

CATEGORY 2: PARTIAL DISCHARGE AT WOODHOUSE TERMINAL

This category involves all vessels that had to call at the Woodhouse Terminal to partially discharge their load before proceeding to a city dock. The vessels had to draft at least 32 ft inbound in order to be considered for the analysis. Anything less than 32 ft would be able to call at the city docks without a partial discharge.

Selection and Data Acquisition

All inbound vessel calls with a sailing draft greater than 32 ft in the Houston Pilots log file were examined to see if they called first at Woodhouse Terminal and then proceeded to a city dock. It was assumed that if the vessel drafted less than 32 ft, the purpose of a call at Woodhouse Terminal would not be to address draft issues. Conversely, it was assumed that if a vessel drafted more than 32 ft, it called at the Woodhouse Terminal in order to reduce its draft. Table 8 shows the number of vessel calls that were selected.

Table 8. Vessels Partially Discharging at Woodhouse Terminal

	# Calls	
	Actual	Minus 1 ft
2008	9	25
2009	2	7

Valuation

The primary costs to consider are additional labor, drayage from Woodhouse to the city dock, and double fees for tugs and pilots. Estimates for drayage were based on information provided by stevedores. The tug and pilot charges were obtained from published tariffs for 2009. Dockage was not considered; when a vessel calls at two Port of Houston docks, the dockage meter does not reset.

For vessels included in the actual conditions analysis, we first determined the tonnage that was discharged at Woodhouse to reduce vessel drafts to a sufficient level for the vessel to proceed to a city dock. The difference in draft between when the vessel called at Woodhouse Terminal and when it departed were obtained from Houston Pilots records. This difference was multiplied by the TPC factor to calculate the tons that were discharged.

For the minus 1 ft analysis, vessels arriving at Woodhouse with 31 or more ft of draft were considered. Only the docks utilized in the actual conditions analysis were considered. For

vessels not in the actual conditions analysis, there was no historical record of how much had to be discharged to deal with the draft restriction. Therefore, we determined what the new draft limit would be at each dock. We used the difference between this draft and the vessel's draft upon arrival at Woodhouse Terminal to determine the tonnage that would theoretically be discharged.

It was determined that the stevedores in charge of handling vessels that called at city docks were not the operators of the Woodhouse Terminal; thus, personnel from Woodhouse would have to be on hand to supervise activities and ensure that their facilities were not damaged. It is assumed that the cost of additional Woodhouse labor added 25 percent of the standard labor cost for the stevedore.

The stevedores indicated that labor costs amounted to approximately $600/gang-hr. After an extensive literature review, we determined that a gang handling general cargo could be expected to offload approximately 120 tons/hr. Thus, the formula for additional labor costs due to the requirement to partially discharge at Woodhouse Terminal can be described as follows:

Additional labor costs = Tons discharged ÷ 120 tons/hr x (.25 x 600)

Table 9 lists the estimated combined value of the pilot fees, tug fees, drayage costs, and additional labor costs for vessels that required partial cargo discharge at Woodhouse Terminal before proceeding to city docks, under the actual and minus 1 ft conditions.

Table 9. Dollar Effect of Partial Discharges at Woodhouse Terminal

	Dollar Effect	
	Actual	Minus 1 ft
2008	$212,892	$493,539
2009	$44,718	$124,107
TOTAL	$257,610	$617,646

CATEGORY 3: MANEUVERING STERN FIRST

Due to siltation in the Turning Basin, the Houston Pilots established a rule that any vessel drafting more than 28 ft would have to turn in the secondary turning basin located across from City Dock 26 rather than in the primary Turning Basin. This would require the vessel to move stern first either going to or departing from the dock where the cargo operation takes place. Therefore, this category involves vessels that called at a dock upstream from City Dock 26 that had an inbound and outbound draft that were both greater than 28 ft. It was assumed that if either draft was less than 28 ft, it was not necessary to utilize this alternate procedure, although in practice, it might be required on occasion because of the vessel design. Thus, the number of vessel calls included in this category is likely to be conservative.

Selection and Data Acquisition

All vessels that called at an eligible dock upstream from City Dock 26 were analyzed, and those that drafted more than 28 ft in both directions were selected. Table 10 shows the number of vessel calls that were selected.

Table 10. Vessel Calls for Maneuvering Stern First

	# calls
2008 Actual	129
2008 Minus 1 ft	170
2009 Actual	63
2009 Minus 1 ft	80

Valuation

The tug companies do not charge extra for this move. The direct cost involved in this move consists of an additional pilot. For vessel calls that involved at least one shift to or from the selected dock, the shift fee for one pilot was included. For vessels calls that came in directly from and went directly out to sea (no shifts were involved), the zone charge for one pilot was included. The resultant costs are shown in Table 11.

Table 11. Dollar Effect of Maneuvering Stern First

	Total Extra Expense	
	Actual	Minus 1 ft
2008	$306,771	$415,272
2009	$163,352	$206,006
TOTAL	$470,123	$621,278

CATEGORY 4: DAYLIGHT RESTRICTIONS

The Houston Pilots, in their navigation guidelines, have stated that any vessel exceeding 750 ft Length Overall (LOA) or 39 ft draft will be restricted to daylight passage only in the area above the Shell Oil docks. The LOA limit would not change, even if the channels were perfectly maintained; therefore, it was not included in the analysis. Because the restriction is partially based on vessel draft, the effect of the restriction is associated with actual conditions. It is assumed that if the channel had a loss of 1 ft available draft, the daylight restriction would be reduced by 1 ft to vessels with a 38-ft draft.

Selection and Data Acquisition

All vessels that exceeded 39-ft sailing draft and called at any dock above the Shell Oil docks were included. Table 12 shows the number of calls that were affected.

Table 12. Vessel Calls Subject to Daylight Restriction

	# Moves
2008 Actual	67
2008 Minus 1 ft	136
2009 Actual	64
2009 Minus 1 ft	99

Valuation

It was assumed that vessel arrivals and departures are random events in terms of timing. For the sake of simplicity, it was also assumed that vessel transits above the Shell Oil docks would be restricted during 12 hours of each 24-hour day. Therefore, the entire set of selected vessels identified as transiting above the Shell Oil docks would experience a three-hour delay on average. (Assuming random vessel arrivals, 50 percent would experience no delay, and 50 percent would experience an average of six hours of delay; therefore, the combined average is three hours.)

Dockage beyond the first 24 hours in port is charged in 12-hour increments; therefore, any vessel that is restricted from departing will incur an additional 12-hour dockage charge. Additionally, it will, on the average, incur the cost of 3 additional hours of port time either at the dock or at anchorage. The dockage fee and the security surcharge were taken from the Port of Houston Tariff No. 8, dated November 27, 2007 for the 2008 activity. Port of Houston Tariff No. 8, dated November 25, 2008 was used for the 2009 activity. The in-port operating costs were obtained from the Corp's Institute for Water Resources.

The estimated operating cost increases due to daylight restrictions are shown in Table 13.

Table 13. Dollar Effect of Daylight Restrictions

	Dollar Effect	
	Actual	Minus 1 ft
2008	$318,062	$611,159
2009	$397,857	$592,342
TOTAL	$715,919	$1,203,501

CATEGORY 5: LIGHT LOADING CONTAINER SHIPMENTS

Information provided by container lines suggests that the actual channel depth was generally maintained at the designed depth of 40' for this period and therefore they have been able to operate as planned to date. Representatives of these lines were careful to point out that container ships are continually increasing in size (width and depth); the current authorized dimensions of the HSC prevent them from maximizing the opportunity of their vessel capacity at the Port of Houston. The lines have indicated that it is desirable to have a 45-ft channel draft at Barbours Cut Terminal and Bayport Terminal. A lack of maintenance dredging compounds the effects of an already inefficient channel design.

Inbound shipments would not ordinarily be affected by a 1-ft reduction in channel depth because most inbound containers contain lower-density cargos, and most actual container weights are less than the maximum allowable container weights. This reduces the tonnage of loaded inbound vessels and reduces the required draft to less than current channel depth. However, outbound shipments tend to consist of higher density cargoes where the container's maximum weight is reached before it is filled. Thus, any reduction in channel depth for outbound containerized cargoes could have a serious effect on container line revenues. This category analyzes outbound container shipments and evaluates the potential effect of a loss of 1 ft of channel depth from actual conditions.

Selection and Data Acquisition

There was no apparent effect in 2008–2009 under actual conditions. Vessels drafted 40 ft at both Barbours Cut and Bayport. However, because they were utilizing maximum draft, a reduction in draft would directly affect a number of shipments. All outbound vessels that drafted more than 39 ft in 2008–2009 were selected for this analysis. Table 14 shows the number of vessels that were selected.

Table 14. Container Vessel Departures Drafting More than 39 ft

	# Sailings
2008 Minus 1 ft	42
2009 Minus 1 ft	92

Valuation

The TPC factors for container vessels included in this category were used to calculate the number of tons that would be affected by a 1 ft reduction in draft. The tonnage was totaled for

these vessel sailings. Information provided by one of the major container lines serving the Port of Houston suggests that a container line loses about $1,000 for every TEU[r] it gives up (freight and terminal charges). An average of 13 mt/TEU (an average indicated by the container line) was used to estimate the number of TEUs affected. Thus, the value of lost container line revenue due to light loading under a loss of 1 ft draft scenario equals the total affected tonnage divided by 13 and then multiplied by $1,000. Table 15 shows the dollar amount of the effect.

Table 15. Dollar Effect of Light Loading (containerized)

	Dollar Effect
2008 Minus 1 ft	$4,368,000
2009 Minus 1 ft	$11,515,000

[r] A "TEU" is a 20-ft equivalent unit. A 20-ft container is one TEU; a 40-ft container is 2 TEU. This is the unit of measure typically used in the container business.

SUMMARY OF EFFECTS BY YEAR AND "ACTUAL" VS. "ACTUAL MINUS 1 FT"

Table 16 summarizes the total impacts included in this analysis. The totals are presented for both the actual conditions and the actual conditions minus 1 ft.

Table 16. Summary of Effects

Year	Actual	Actual Minus 1 ft
2008	$37,410,605	$281,881,885
2009	$15,288,003	$90,962,018
Total	$52,698,608	$372,843,903

The large majority of estimated economic impacts of HSC maintenance are due to "light loading" of vessels carrying non-containerized cargoes, and most of these losses are associated with lost business opportunities, followed by increases in unit costs of transport. Under actual conditions, estimated HSC losses totaled over $52 million in 2008-2009. There were no estimated losses due to light loading for containerized cargoes under actual conditions based on information provided by container lines.

Assuming an additional loss of 1 ft of available draft from actual conditions in 2008-2009, HSC losses would total nearly $373 million in 2008-2009. As with estimates for actual conditions, lost business opportunities due to light loading of non-containerized vessels accounts for a high percentage of impacts. The proportion of unit cost increases due to light loading of these vessels compared with losses under actual conditions increased from around 4 percent of total impacts to around 11 percent. With a 1-ft loss in available draft, containerized trade losses would be nearly $16 million over the time period.

Since estimates were generated for 2008-2009—years in which maritime trade was significantly reduced from previous years in which economic growth was occurring—the impacts of such efficiencies may be potentially greater than estimated for this study with an economic rebound.

The over seven-fold increase in estimated economic losses with a loss of 1 ft of available draft in the Houston Ship Channel suggests the significance of HSC maintenance to HSC users, the Port of Houston, and Southeast Texas. The sharp increase in economic losses with a loss of only 1 ft of available draft suggests that many vessels calling to and from berths along the HSC are operating to the maximum degree allowed by current channel depth.

APPENDIX A:
DOCK CODES WITH DRAFT INFORMATION

DOCK CODE LISTING WITH MAXIMUM SAILING DRAFTS[s]

CODE	*DOCK NAME*	*AUTHORIZED CHANNEL LIMITATION*	*DOCK DESIGN DRAFT LIMITATION*	*Lesser Limitation*	*Ignore Flag*	*COMMENTS*	*Max Sailing Draft 2008 (ft)*	*Max Sailing Draft 2009 (ft)*
272	Sea, 272 Rule	N/A	N/A	0	1	Depth is irrelevant		
310	Sea. 310 Rule	N/A	N/A	0	1	Depth is irrelevant		
AG1	AGRIFOS 1	40	35	35	1		35.0000	35.0000
AG2	AGRIFOS 2	40	35	35	1		34.6667	35.0000
BC1	BARBOURS CUT 1	40	42	40	1		38.7500	39.3330
BC2	BARBOURS CUT 2	40	42	40	1		40.0000	40.0000
BC3	BARBOURS CUT 3	40	42	40	1		40.0000	40.0000
BC4	BARBOURS CUT 4	40	42	40	1		40.1667	39.6667
BC5	BARBOURS CUT 5	40	42	40	1		40.0000	39.3333
BC6	BARBOURS CUT 6	40	42	40	1		40.0000	40.0000
BC7	BARBOURS CUT 7	40	33	33	1		34.0000	32.2050
BC8	BARBOURS CUT 8	N/A	N/A	0	1		0.0000	0.0000
BCL	BARBOURS CUT LASH	40	40	40	1	BC2-BC6 show that channel is not a restriction here	35.0000	33.0000
BCR	BARBOURS CUT RO/RO	40	N/A	40	1		0.0000	0.0000
BI	BRADY ISLAND	N/A	N/A	0	1		26.7500	0.0000
BLD	BULK PLANT (LOAD)	40	42	40	1		40.0000	39.5000
BLY	BULK PLANT (LAY BERTH)	N/A	N/A	0	1		0.0000	0.0000

[s] Amber shading indicates that dock is not relevant due to location or lack of draft.
Gray shading indicates no eligible activity.

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
BP1	BAYPORT CONTAINER 1	42	40	40	1		0.0000	0.0000
BP2	BAYPORT CONTAINER 2	42	40	40	1		0.0000	0.0000
BP3	BAYPORT CONTAINER 3	42	40	40	1		0.0000	0.0000
BP4	BAYPORT CONTAINER 4	42	40	40	1		40.0000	40.0000
BP5	BAYPORT CONTAINER 5	42	40	40	1		40.0000	40.0000
BP6	BAYPORT CONTAINER 6	42	40	40	1		0.0000	0.0000
BP7	BAYPORT CONTAINER 7	42	40	40	1		0.0000	0.0000
C10	CITY DOCK 10	36	33	33			30.0833	31.0000
C11	CITY DOCK 11	36	33	33			30.5000	26.6667
C12	CITY DOCK 12	36	33	33			32.0000	32.0000
C13	CITY DOCK 13	36	33	33	1		28.5000	27.0000
C14	CITY DOCK 14	36	34	34	1		31.1667	19.5000
C15	CITY DOCK 15	36	34	34	1		0.0000	0.0000
C16	CITY DOCK 16	36	38	36			36.0000	34.7500
C17	CITY DOCK 17	36	38	36	1		35.4167	35.5000
C18	CITY DOCK 18	36	38	36			35.3333	35.0000
C19	CITY DOCK 19	36	38	36	1		36.0000	32.5000
C1E	CITY DOCK 1 EAST	36	34	34	1		32.0000	28.0000
C1W	CITY DOCK 1 WEST	36	34	34	1		31.5000	28.0000

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
C2	CITY DOCK 2	36	33	33			33.0000	27.9167
C20	CITY DOCK 20	36	38	36	1		36.0000	35.4167
C21	CITY DOCK 21	36	38	36	1		36.0000	35.3333
C22	CITY DOCK 22	36	38	36	1		36.0000	31.0000
C23	CITY DOCK 23	36	38	36	1		36.0000	35.8333
C24	CITY DOCK 24	36	38	36	1		36.0000	34.0000
C25	CITY DOCK 25	36	38	36	1		35.7500	33.8333
C26	CITY DOCK 26	36	38	36	1		36.8333	35.4167
C27	CITY DOCK 27	36	38	36	1		35.6667	33.0000
C28	CITY DOCK 28	36	38	36	1		36.0833	32.5000
C29	CITY DOCK 29	36	38	36	1		36.0000	34.3333
C3	CITY DOCK 3	36	33	33			30.0000	25.0000
C30	CITY DOCK 30	36	38	36	1		35.8333	33.8333
C31	CITY DOCK 31	36	38	36	1		29.0000	35.0000
C32	CITY DOCK 32	36	38	36	1		36.4167	34.2500
C4	CITY DOCK 4	36	27/32	36	1		26.4167	22.7500
C41	CITY DOCK 41	36	32	32	1		0.0000	27.9167
C42	CITY DOCK 42	36	32	32	1		0.0000	0.0000
C43	CITY DOCK 43	36	32	32	1		0.0000	23.3333
C44	CITY DOCK 44	36	32	32	1		0.0000	0.0000
C45	CITY DOCK 45	36	32	32	1		0.0000	0.0000
C46	CITY DOCK 46	36	32	32	1		0.0000	0.0000
C47	CITY DOCK 47	36	35	35	1		36.0000	32.6670
C48	CITY DOCK 48	36	35	35	1		19.6667	34.5000
C8	CITY DOCK 8	36	38	36			34.2500	26.9170
C9	CITY DOCK 9	36	34	34			32.0000	26.0000

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
CBU	Carpenter's Bayou	N/A	N/A	0	1		19.0000	14.0000
CG1	CARGILL 1	45	40	40	1		40.0000	39.0000
CG2	CARGILL 2	45	40	40	1		39.6667	40.0000
CG3	CARGILL 3	45	34	34	1		33.5000	33.8330
CMX	CEMEX	45	39	39	1		38.0000	34.9167
CP4	CHEVRON PHILLIPS 4	40	40	40	1		0.0000	0.0000
CP5	CHEVRON PHILLIPS 5	40	40	40	1		0.0000	0.0000
CP6	CHEVRON PHILLIPS 6	40	40	40	1		0.0000	0.0000
CP7	CHEVRON PHILLIPS 7	40	40	40	1	Once listed as BP AMOCO 7	0.0000	0.0000
CP8	CHEVRON PHILLIPS 8	40	40	40	1		0.0000	0.0000
CP9	CHEVRON PHILLIPS 9	40	40	40	1		0.0000	0.0000
CT1	BAYPORT CRUISE 1	N/A	33	33	1		27.5833	33.0000
CT2	BAYPORT CRUISE 2	N/A	N/A	0	1		0.0000	0.0000
CT3	BAYPORT CRUISE 3	N/A	N/A	0	1		0.0000	0.0000
ETL	ETHYL	45		45	1		0.0000	0.0000
EX1	EXXON 1	45	42	42		Per terminal	38.0000	38.0000
EX2	EXXON 2	45	42	42		Per terminal	39.0833	35.9167
EX3	EXXON 3	45	42	42		Per terminal	38.4167	37.8330
EX4	EXXON 4	45	42	42		Barge only	0.0000	0.0000

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
EX5	EXXON 5	45	44.5	44.5		Per terminal	40.0000	42.5000
EX6	EXXON 6	45	44.5	44.5		Per terminal	42.0000	42.0000
GBU	Greens Bayou Dock	45	42	42	1		19.0000	18.5000
GG	GEORGIA GULF	40	36	36	1		29.0000	28.5000
GPE	GREENSPORT EAST	40	40	40	1		43.5000	37.3333
GPM	GREENSPORT MIDDLE	40	40	40	1		16.2500	0.0000
GPR	GREENSPORT RORO	40	40	40	1		0.0000	0.0000
GPW	GREENSPORT WEST	40	40	40	1		38.4167	37.9167
GX	Galveston	N/A	N/A	0	1		40.0000	38.5000
GYP	US GYPSUM	36	20	20	1		0.0000	0.0000
HAM	HOUSTON AMMONIA	40	32	32	1		32.9167	31.1667
HCE	HOUSTON CEMENT EAST	40	42	40	1	Per terminal - New (since 2001)	39.5000	38.9167
HCW	HOUSTON CEMENT WEST	40	40	40		Per terminal	39.0000	39.0000
HF1	HOUSTON FUEL OIL 1	45	45	45	1	Per terminal	45.0000	45.0000
HF2	HOUSTON FUEL OIL 2	45	40	40	1	Per terminal	40.1667	40.1667
HF3	HOUSTON FUEL OIL 3	45	45	45	1	Per terminal	45.0000	45.0000
IC1	INTERCONT. TERM. CO. 1	45	40	40	1	Per terminal	38.6667	40.0000

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
IC2	INTERCONT. TERM. CO. 2	45	40	40	1	Per terminal	38.5000	39.0833
IC3	INTERCONT. TERM. CO. 3	45	28	28	1	Per terminal	27.2500	27.9167
IC7	INTERCONT. TERM. CO. 7	45	45	45	1	Per terminal--deepened in 2009	39.5000	43.5000
IC8	INTERCONT. TERM. CO. 8	45	45	45	1	Per terminal--deepened in 2009	40.0000	43.5000
INB	INBESA	45	34	34	1		34.0000	33.8333
IT2	INDUSTRIAL TERMINALS 2	40	36	36	1	Per Gulf Stream Marine (IT dock is now South Central Cement) - dredged to 40 at end of 2009	36.5000	30.5000
ITE	INDUSTRIAL TERMINAL EAST	0	29	29	1	Per terminal - Was "Joe D. Hughes"	28.0000	23.0000
ITW	INDUSTRIAL TERMINAL WEST	0	29	29	1	Per terminal - Was "Joe D. Hughes"	25.0000	25.2500
JC1	JACINTOPORT 1	45	40	40	1	per PHA - 38.5 per pilots	38.0000	32.0000
JC2	JACINTOPORT 2	45	40	40	1	per PHA - 37 per pilots	34.5000	30.0000
JC3	JACINTOPORT 3	45	40	40	1	per PHA - 37 per pilots	39.0000	38.5000
JC4	JACINTOPORT 4	45	36	36	1		36.5833	31.0833
JC5	JACINTOPORT S	45	38	38	1		38.0000	37.9167
KAV	KAVANAGH	40	34	34	1	Per terminal - New (since 2001)	27.0000	26.7500
KER	KERLEY	40	25	25	1		34.1667	0.0000
KM1	KINDER MORGAN 1	40	40	40	([t])	Per terminal	39.0000	37.5000

[t] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
KM2	KINDER MORGAN 2	40	40	40	1	Per terminal	38.0000	38.0000
KM3	KINDER MORGAN 3	40	40	40	1	Per terminal	39.5000	39.3333
KM4	KINDER MORGAN 4	40	40	40	1	Per terminal - New (since 2001)	39.1667	40.0000
KMD	KINDER MORGAN DEEPWATER	40	40	40	1	Per terminal - New (since 2001)	40.0000	42.0000
KMP	KINDER MORGAN PASADENA	40	39	39	1		33.0000	0.0000
LB1	LBC1	40	40	40	1		39.2500	39.3333
LB2	LBC2	40	40	40	1		40.0000	39.3333
LB3	LBC3	40	40	40	1	Other docks @ Bayport are maxed	39.5000	38.6667
LYB	LYONDELL B	40	40	40	1		36.0000	32.8333
LYC	LYONDELL C	40	39	39	1		32.0000	33.8333
MG1	MAGELLAN 1	40	40	40	1		44.3333	40.0000
MG2	MAGELLAN 2	40	40	40	1		39.0000	40.0000
MNA	MANCHESTER A	36	34	34	1	Per terminal (A,B,C = 1500')	28.4167	32.0000
MNB	MANCHESTER B	36	34	34	1	Per terminal (A,B,C = 1500')	30.0000	31.1670
MNC	MANCHESTER C	36	34	34	1	Per terminal (A,B,C = 1500')	35.1667	29.8333
MND	MANCHESTER D	36	24	24	1	Per terminal (D,E,F = 1700')	24.0000	23.5833
MNE	MANCHESTER E	36	24	24	1	Per terminal (D,E,F = 1700')	23.3333	24.0000
MNF	MANCHESTER F	36	24	24	1	Per terminal (D,E,F = 1700')	15.0000	0.0000
MNG	MANCHESTER G	36		36	1		0.0000	0.0000
MP-	Turning Basin Below Morgan's Point	N/A	N/A	0	1		40.7500	35.8333

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
MP+	Turning Basin Above Morgan's Point	N/A	N/A	0	1		38.5000	37.0000
NPP	NEWPARK PASADENA			0	1		0.0000	0.0000
NT1	NEW TERMINAL 1	36	34	34	1		21.0000	32.0000
NT2	NEW TERMINAL 2	36	34	34	1		18.4167	28.8333
OD1	ODFJELL 1	40	40	40	1	Per website - 38.5 per pilots	39.7500	39.5833
OD2	ODFJELL 2	40	40	40	1	Per website - 36 per pilots	39.0000	35.7500
OD3	ODFJELL 3	15		15	1		0.0000	0.0000
OM2	OLD MANCHESTER 2	36	36	36	1		33.5000	33.5000
OM3	OLD MANCHESTER 3	36	36	36	1		36.9167	35.5000
OT1	OILTANKING 1	45	40	40	1	Per terminal	40.0000	40.3333
OT2	OILTANKING 2	45	40	40	1	Per Terminal (Was "Stolt Haven")	40.0000	39.4167
OT3	OILTANKING 3	45	40	40	1	Per Terminal (Was "Stolt Haven")	39.5000	40.0000
OT4	OILTANKING 4	45	40	40	1	Per terminal	39.7500	40.0000
OT5	OILTANKING 5	45	45	45	1	Per terminal	44.9167	45.0000
OT6	OILTANKING 6	45	45	45	1	Per terminal	45.0000	45.0000
OT7	OILTANKING 7	45	40	40	1	Per terminal (New (since 2001))	40.0000	40.0000
OT8	OILTANKING 8	45	40	40	1	Per terminal	39.8333	40.0000
OTB	OILTANKING BARGE DOCK	N/A	N/A	0	1		0.0000	0.0000
PRS	PASADENA REFINING	40	35	35	1		38.6670	38.0000
PXA	PETROTEX A	40	45	40	1		28	37.5833

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
PXB	PETROTEX B		38	38	1		0.0000	0.0000
RD	Bolivar Roads	N/A	N/A	0	1	Depth is irrelevant	34.4167	35.0833
RD2	Bolivar Roads, 272 Rule	N/A	N/A	0	1	Depth is irrelevant	0.0000	31.1667
RD4	Bolivar Roads, Anchorage, 4 Hour	N/A	N/A	0	1	Depth is irrelevant	31.0000	29.3333
RDP	Bolivar Roads, Anchorage to Galveston	N/A	N/A	0	1	Depth is irrelevant	35.5000	37.7500
RDT	Bolivar Roads, Turning Basin	N/A	N/A	0	1	Depth is irrelevant	0.0000	36.7500
SE4	Sea, 4 Hour Rule	N/A	N/A	0	1	Depth is irrelevant	42.0000	40.0000
SEA	Sea, 8 Hour Rule	N/A	N/A	0	1	Depth is irrelevant	45.0000	45.0000
SEP	Sea, Proceed not before	N/A	N/A	0	1	Depth is irrelevant	0.0000	0.0000
SH2	SHELL 2	45	40	40	1	Per terminal ("Center dock")	37.4167	36.0833
SH3	SHELL 3	45		45	1		0.0000	0.0000
SHC	SHELL CRUDE	45	45	45	([u])	Per terminal	44.0000	43.0000
SHE	SHELL EAST	45	40	40	1	Per terminal	39.5000	36.7500
SHW	SHELL WEST	45	40	40	1	Per terminal	39.3330	37.0000
TC	Texas City	N/A	N/A	0	1		38.0000	39.5000
TCP	Texas City, Proceed not before	N/A	N/A	0	1		0.0000	29.5000
TG1	TARGA 1	40	38	38	1		31.4167	35.1667

[u] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
TG2	TARGA 2	40	40	40	1		33.7500	29.8333
TG5	TARGA 5	40	42	40	1		37.3330	34.4167
TX1	TEXAS T CHANNEL SIDE	36	30	30	1	("Texas Terminals")	27.9167	32.5000
TX2	TEXAS T SLIP	36	30	30	1	("Texas Terminals")	27.5833	27.5833
VAL	VALERO	36	42	36	1		0.0000	0.0000
VP1	VOPAK 1	45	40	40	1		39.3333	40.0000
VP2	VOPAK 2	45	40	40	1		40.0000	40.0000
VP3	VOPAK 3	45	40	40	1		39.1667	39.1667
VPG	VOPAK GALENA	40	34	34	1		32.8330	32.8333
VUL	VULCAN	40	41	40	1		40.0000	38.6667
WH1	WOODHOUSE 1	40	39	39	1		40.0000	38.0000
WH2	WOODHOUSE 2	40	35	35	1		35.0000	34.5833
WH3	WOODHOUSE 3	40	35	35	1		32.1667	34.1667
WH4	WOODHOUSE 4	40	42	40	1		33.9167	40.0000
WT2	WESTWAY TERMINAL 2	36	33	33	1		33.9167	34.0000

DOCK CODE LISTING WITH MAXIMUM SAILING DRAFTS - minus 1 foot[v]

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
272	Sea, 272 Rule	N/A	N/A	0	1	Depth is irrelevant		
310	Sea. 310 Rule	N/A	N/A	0	1	Depth is irrelevant		
AG1	AGRIFOS 1	39	35	35	1		35.0000	35.0000
AG2	AGRIFOS 2	39	35	35	1		34.6667	35.0000
BC1	BARBOURS CUT 1	39	42	39	([w])		38.7500	38.3330
BC2	BARBOURS CUT 2	39	42	39			39.0000	39.0000
BC3	BARBOURS CUT 3	39	42	39			39.0000	39.0000
BC4	BARBOURS CUT 4	39	42	39			39.1667	38.6667
BC5	BARBOURS CUT 5	39	42	39			39.0000	38.3330
BC6	BARBOURS CUT 6	39	42	39			39.0000	39.0000
BC7	BARBOURS CUT 7	39	33	33	1		34.0000	32.2500
BC8	BARBOURS CUT 8	N/A	N/A	0	1		0.0000	0.0000
BCL	BARBOURS CUT LASH	39	40	39	1	BC2-BC6 show that channel is not a restriction here	35.0000	33.0000
BCR	BARBOURS CUT RO/RO	40	N/A	40	1		0.0000	0.0000

[v] Amber shading indicates that dock is not relevant due to location or lack of draft. Gray shading indicates no eligible activity.
[w] Only affected in 2009

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
BI	BRADY ISLAND	N/A	N/A	0	1		26.7500	0.0000
BLD	BULK PLANT (LOAD)	39	42	39			39.0000	38.5000
BLY	BULK PLANT (LAY BERTH)	N/A	N/A	0	1		0.0000	0.0000
BP1	BAYPORT CONTAINER 1	42	40	40	1		0.0000	0.0000
BP2	BAYPORT CONTAINER 2	42	40	40	1		0.0000	0.0000
BP3	BAYPORT CONTAINER 3	42	40	40	1		0.0000	0.0000
BP4	BAYPORT CONTAINER 4	41	40	40	1		40.0000	40.0000
BP5	BAYPORT CONTAINER 5	41	40	40	1		40.0000	40.0000
BP6	BAYPORT CONTAINER 6	42	40	40	1		0.0000	0.0000
BP7	BAYPORT CONTAINER 7	42	40	40	1		0.0000	0.0000
C10	CITY DOCK 10	35	33	33			29.0833	30.0000
C11	CITY DOCK 11	35	33	33			29.5000	26.6667
C12	CITY DOCK 12	35	33	33			31.0000	31.0000
C13	CITY DOCK 13	35	33	33	1		28.5000	27.0000
C14	CITY DOCK 14	35	34	34			30.1667	19.5000
C15	CITY DOCK 15	36	34	34	1		0.0000	0.0000
C16	CITY DOCK 16	35	38	35			35.0000	33.7500
C17	CITY DOCK 17	35	38	35			34.4170	34.5000

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
C18	CITY DOCK 18	35	38	35			34.3330	34.0000
C19	CITY DOCK 19	35	38	35	(x)		35.0000	32.5000
C1E	CITY DOCK 1 EAST	36	34	34	1		32.0000	28.0000
C1W	CITY DOCK 1 WEST	36	34	34	1		31.5000	28.0000
C2	CITY DOCK 2	35	33	33			33.0000	27.9167
C20	CITY DOCK 20	35	38	35			35.0000	34.4170
C21	CITY DOCK 21	35	38	35			35.0000	34.3330
C22	CITY DOCK 22	35	38	35	(x)		35.0000	31.0000
C23	CITY DOCK 23	35	38	35			35.0000	34.8333
C24	CITY DOCK 24	35	38	35	(x)		35.0000	34.0000
C25	CITY DOCK 25	35	38	35			34.7500	33.8333
C26	CITY DOCK 26	35	38	35			35.8330	34.4170
C27	CITY DOCK 27	35	38	35	(x)		34.6670	33.0000
C28	CITY DOCK 28	35	38	35	(x)		35.0830	32.5000
C29	CITY DOCK 29	35	38	35	(x)		35.0000	34.3333
C3	CITY DOCK 3	35	33	33			30.0000	25.0000
C30	CITY DOCK 30	35	38	35	(x)		34.8330	33.8333
C31	CITY DOCK 31	35	38	35	(y)		29.0000	34.0000
C32	CITY DOCK 32	35	38	35	(x)		35.4170	34.2500
C4	CITY DOCK 4	36	27/32	36	1		26.4167	22.7500
C41	CITY DOCK 41	36	32	32	1		0.0000	27.9167
C42	CITY DOCK 42	36	32	32	1		0.0000	0.0000

[x] Only affected in 2008
[y] Only affected in 2009

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
C43	CITY DOCK 43	36	32	32	1		0.0000	23.3333
C44	CITY DOCK 44	36	32	32	1		0.0000	0.0000
C45	CITY DOCK 45	36	32	32	1		0.0000	0.0000
C46	CITY DOCK 46	36	32	32	1		0.0000	0.0000
C47	CITY DOCK 47	35	35	35	([z])		35.0000	32.6667
C48	CITY DOCK 48	35	35	35	1		19.6667	34.5000
C8	CITY DOCK 8	35	38	35			33.2500	25.9170
C9	CITY DOCK 9	35	34	34			31.0000	25.0000
CBU	Carpenter's Bayou	N/A	N/A	0	1		19.0000	14.0000
CG1	CARGILL 1	44	40	40	1		40.0000	39.0000
CG2	CARGILL 2	44	40	40	1		39.6667	40.0000
CG3	CARGILL 3	44	34	34	1		33.5000	33.8300
CMX	CEMEX	44	39	39	1		38.0000	34.9170
CP4	CHEVRON PHILLIPS 4	39	40	39	1		0.0000	0.0000
CP5	CHEVRON PHILLIPS 5	39	40	39	1		0.0000	0.0000
CP6	CHEVRON PHILLIPS 6	39	40	39	1		0.0000	0.0000
CP7	CHEVRON PHILLIPS 7	39	40	39	1	Once listed as BP AMOCO 7	0.0000	0.0000
CP8	CHEVRON PHILLIPS 8	39	40	39	1		0.0000	0.0000
CP9	CHEVRON PHILLIPS 9	39	40	39	1		0.0000	0.0000

[z] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
CT1	BAYPORT CRUISE 1	N/A	33	33	1		27.5833	33.0000
CT2	BAYPORT CRUISE 2	N/A	N/A	0	1		0.0000	0.0000
CT3	BAYPORT CRUISE 3	N/A	N/A	0	1		0.0000	0.0000
ETL	ETHYL	44		44	1		0.0000	0.0000
EX1	EXXON 1	44	42	42		Per terminal	37.0000	37.0000
EX2	EXXON 2	44	42	42		Per terminal	38.0833	34.9167
EX3	EXXON 3	44	42	42		Per terminal	37.4167	36.8333
EX4	EXXON 4	44	42	42	1	Barge only	0.0000	0.0000
EX5	EXXON 5	44	44.5	44		Per terminal	39.0000	41.5000
EX6	EXXON 6	44	44.5	44		Per terminal	41.0000	41.0000
GBU	Greens Bayou Dock	44	42	42	1		19.0000	18.5000
GG	GEORGIA GULF	39	36	36	1		29.0000	28.5000
GPE	GREENSPORT EAST	39	40	39			42.5000	36.3330
GPM	GREENSPORT MIDDLE	40	40	40	1		16.2500	0.0000
GPR	GREENSPORT RORO	40	40	40	1		0.0000	0.0000
GPW	GREENSPORT WEST	39	40	39	1		38.4167	37.9170
GX	Galveston	N/A	N/A	0	1		40.0000	38.5000
GYP	US GYPSUM	35	20	20	1		0.0000	0.0000
HAM	HOUSTON AMMONIA	39	32	32	1		32.9167	31.1670

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
HCE	HOUSTON CEMENT EAST	39	42	39	([aa])	Per terminal - New (since 2001)	38.5000	38.9167
HCW	HOUSTON CEMENT WEST	39	40	39		Per terminal	38.0000	38.0000
HF1	HOUSTON FUEL OIL 1	44	45	44		Per terminal	44.0000	44.0000
HF2	HOUSTON FUEL OIL 2	44	40	40	1	Per terminal	40.1667	40.1670
HF3	HOUSTON FUEL OIL 3	44	45	44		Per terminal	44.0000	44.0000
IC1	INTERCONT. TERM. CO. 1	44	40	40	1	Per terminal	38.6667	40.0000
IC2	INTERCONT. TERM. CO. 2	44	40	40	1	Per terminal	38.5000	39.0830
IC3	INTERCONT. TERM. CO. 3	45	28	28	1	Per terminal	27.2500	27.9167
IC7	INTERCONT. TERM. CO. 7	44	45	44	1	Per terminal--deepened in 2009	39.5000	43.5000
IC8	INTERCONT. TERM. CO. 8	44	45	44	1	Per terminal--deepened in 2009	40.0000	43.5000
INB	INBESA	44	34	34	1		34.0000	33.8330
IT2	INDUSTRIAL TERMINALS 2	39	36	36	1	Per Gulf Stream Marine (IT dock is now South Central Cement) - dredged to 40 at end of 2009	36.5000	30.5000

[aa] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
ITE	INDUSTRIAL TERMINAL EAST	0	29	0	1	Per terminal - Was "Joe D. Hughes"	28.0000	23.0000
ITW	INDUSTRIAL TERMINAL WEST	0	29	0	1	Per terminal - Was "Joe D. Hughes"	25.0000	25.2500
JC1	JACINTOPORT 1	44	40	40	1	per PHA - 38.5 per pilots	38.0000	32.0000
JC2	JACINTOPORT 2	44	40	40	1	per PHA - 37 per pilots	34.5000	30.0000
JC3	JACINTOPORT 3	44	40	40	1	per PHA - 37 per pilots	39.0000	38.5000
JC4	JACINTOPORT 4	44	36	36	1		36.5833	31.0800
JC5	JACINTOPORT S	44	38	38	1		38.0000	37.9200
KAV	KAVANAGH	40	34	34	1	Per terminal - New (since 2001)	27.0000	26.7500
KER	KERLEY	40	25	25	1		34.1667	0.0000
KM1	KINDER MORGAN 1	39	40	39	([bb])	Per terminal	38.0000	37.5000
KM2	KINDER MORGAN 2	39	40	39	1	Per terminal	38.0000	38.0000
KM3	KINDER MORGAN 3	39	40	39		Per terminal	38.5000	38.3330
KM4	KINDER MORGAN 4	39	40	39		Per terminal - New (since 2001)	38.1670	39.0000
KMD	KINDER MORGAN DEEPWATER	39	40	39		Per terminal - New (since 2001)	39.0000	41.0000
KMP	KINDER MORGAN PASADENA	39	39	39	1		33.0000	0.0000
LB1	LBC1	39	40	39			38.2500	38.3330

[bb] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
LB2	LBC2	39	40	39			39.0000	38.3330
LB3	LBC3	39	40	39	([cc])		38.5000	38.6667
LYB	LYONDELL B	39	40	39	1		36.0000	32.8300
LYC	LYONDELL C	39	39	39	1		32.0000	33.8300
MG1	MAGELLAN 1	39	40	39		Mark McKenzie - 281-477-7814	43.3330	39.0000
MG2	MAGELLAN 2	39	40	39			38.0000	39.0000
MNA	MANCHESTER A	35	34	34	1	Per terminal (A,B,C = 1500')	28.4167	32.0000
MNB	MANCHESTER B	35	34	34	1	Per terminal (A,B,C = 1500')	30.0000	31.1670
MNC	MANCHESTER C	35	34	34	([cc])	Per terminal (A,B,C = 1500')	34.1667	29.8300
MND	MANCHESTER D	36	24	24	1	Per terminal (D,E,F = 1700')	24.0000	23.5833
MNE	MANCHESTER E	36	24	24	1	Per terminal (D,E,F = 1700')	23.3333	24.0000
MNF	MANCHESTER F	36	24	24	1	Per terminal (D,E,F = 1700')	15.0000	0.0000
MNG	MANCHESTER G	35		35	1		0.0000	0.0000
MP-	Turning Basin Below Morgan's Point	N/A	N/A	0	1		40.7500	35.8300
MP+	Turning Basin Above Morgan's Point	N/A	N/A	0	1		38.5000	37.0000
NPP	NEWPARK PASADENA			0	1		0.0000	0.0000
NT1	NEW TERMINAL 1	35	34	34	1		21.0000	32.0000
NT2	NEW TERMINAL 2	35	34	34	1		18.4167	28.8300
OD1	ODFJELL 1	39	40	39		Per website - 38.5 per pilots	38.7500	38.5830

[cc] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
OD2	ODFJELL 2	39	40	39	([dd])	Per website - 36 per pilots	38.0000	35.7500
OD3	ODFJELL 3	15		15	1		0.0000	0.0000
OM2	OLD MANCHESTER 2	35	36	35	1		33.5000	33.5000
OM3	OLD MANCHESTER 3	35	36	35			35.9167	34.5000
OT1	OILTANKING 1	44	40	40	1	Per terminal	40.0000	40.3330
OT2	OILTANKING 2	44	40	40	1	Per Terminal (Was "Stolt Haven")	40.0000	39.4170
OT3	OILTANKING 3	44	40	40	1	Per Terminal (Was "Stolt Haven")	39.5000	40.0000
OT4	OILTANKING 4	44	40	40	1	Per terminal	39.7500	40.0000
OT5	OILTANKING 5	44	45	44		Per terminal	43.9167	44.0000
OT6	OILTANKING 6	44	45	44		Per terminal	44.0000	44.0000
OT7	OILTANKING 7	44	40	40	1	Per terminal (New (since 2001))	40.0000	40.0000
OT8	OILTANKING 8	44	40	40	1	Per terminal	39.8333	40.0000
OTB	OILTANKING BARGE DOCK	N/A	N/A	0	1		0.0000	0.0000
PRS	PASADENA REFINING	39	35	35	1	713.472.2461	38.6670	38.0000
PXA	PETROTEX A	40	45	40	1		28.0000	37.5833
PXB	PETROTEX B	0	38	0	1		0.0000	0.0000
RD	Bolivar Roads	N/A	N/A	0	1	Depth is irrelevant	34.4170	35.0830
RD2	Bolivar Roads ,272 Rule	N/A	N/A	0	1	Depth is irrelevant	0.0000	31.1670

[dd] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
RD4	Bolivar Roads, Anchorage, 4 Hour	N/A	N/A	0	1	Depth is irrelevant	31.0000	29.3330
RDP	Bolivar Roads, Anchorage to Galveston	N/A	N/A	0	1	Depth is irrelevant	35.5000	37.7500
RDT	Bolivar Roads, Turning Basin	N/A	N/A	0	1	Depth is irrelevant	0.0000	36.7500
SE4	Sea, 4 Hour Rule	N/A	N/A	0	1	Depth is irrelevant	42.0000	40.0000
SEA	Sea, 8 Hour Rule	N/A	N/A	0	1	Depth is irrelevant	45.0000	45.0000
SEP	Sea, Proceed not before	N/A	N/A	0	1	Depth is irrelevant	0.0000	0.0000
SH2	SHELL 2	44	40	40	1	Per terminal ("Center dock")	37.4167	36.0800
SH3	SHELL 3	45		45	1		0.0000	0.0000
SHC	SHELL CRUDE	44	45	44	([ee])	Per terminal	43.0000	43.0000
SHE	SHELL EAST	44	40	40	1	Per terminal	39.5000	36.7500
SHW	SHELL WEST	44	40	40	1	Per terminal	39.3330	37.0000
TC	Texas City	N/A	N/A	0	1		38.0000	39.5000
TCP	Texas City, Proceed not before	N/A	N/A	0	1		0.0000	29.5000
TG1	TARGA 1	39	38	38	1		31.4170	35.1670
TG2	TARGA 2	39	40	39	1		33.7500	29.8330
TG5	TARGA 5	39	42	39	1		37.3330	34.4170
TX1	TEXAS T CHANNEL SIDE	35	30	30	1	("Texas Terminals")	27.9167	32.5000

[ee] Only affected in 2008

CODE	DOCK NAME	AUTHORIZED CHANNEL LIMITATION	DOCK DESIGN DRAFT LIMITATION	Lesser Limitation	Ignore Flag	COMMENTS	Max Sailing Draft 2008 (ft)	Max Sailing Draft 2009 (ft)
TX2	TEXAS T SLIP	36	30	30	1	("Texas Terminals")	27.5833	27.5833
VAL	VALERO	35	42	35	1		0.0000	0.0000
VP1	VOPAK 1	44	40	40	1		39.3330	40.0000
VP2	VOPAK 2	44	40	40	1		40.0000	40.0000
VP3	VOPAK 3	44	40	40	1		39.1667	39.1670
VPG	VOPAK GALENA	39	34	34	1		32.8330	32.8300
VUL	VULCAN	39	41	39	([ff])		39.0000	38.6667
WH1	WOODHOUSE 1	39	39	39	([ff])		39.0000	38.0000
WH2	WOODHOUSE 2	39	35	35	1		35.0000	34.5830
WH3	WOODHOUSE 3	39	35	35	1		32.1670	34.1700
WH4	WOODHOUSE 4	39	42	39	([gg])		33.9167	39.0000
WT2	WESTWAY TERMINAL 2	35	33	33	1		33.9170	34.0000

[ff] Only affected in 2008
[gg] Only affected in 2009

APPENDIX B:
DETERMINATION OF COMMODITY VALUES

Grains

Per the Corps' Waterborne Commerce Statistics, the proportions of wheat/sorghum/corn grains shipped to and from the Port of Houston in 2008 was 77/18/5, respectively. Because 2009 data were not available during the analysis, this same split was used for 2009.

Market prices for 2008 and 2009 were obtained from USDA's Economic Research Service publications:

- Wheat Yearbook, Gulf Port Prices.
- Food Grains Yearbook, Corn, Gulf Port Prices for No. 2. Yellow.
- Food Grains Yearbook Sorghum, Gulf Port Prices for No. 2 Yellow.

Weighting the average market prices according to the tonnage split yielded the following grain unit prices for 2008 and 2009:

- 2008: $306.01/MT.[hh]
- 2009: $209.75/MT.

Crude Oil

Price information was obtained from the Energy Information Administration. The specific price used was for "Weekly All Countries Spot Price FOB Weighted by Estimated Export Volume (Dollars per Barrel)." A conversion factor of 7.33 bbl/ metric ton was used to convert barrels to metric tons. This factor is provided by BP on its website.

The crude oil unit prices were as follows:

- 2008: $698.61/MT.
- 2009: $441.69/MT.

Cement

Cement price information was obtained from the USGS Mineral Resources Program. The data available for this analysis ended with 2008. The Producer Price Index for cement was applied to the 2008 price to derive the 2009 value.

[hh] MT = metric ton

The resultant cement unit prices are:

- 2008: $103.00/MT.
- 2009: $101.59/MT.

Limestone

Limestone price information was obtained from the USGS Mineral Resources Program. Data available for this analysis ended with 2008. The Producer Price Index for limestone was applied to the 2008 price to derive the 2009 value.

The resultant limestone unit prices are:

- 2008: $8.24/MT.
- 2009: $8.68/MT.