IHS ECONOMICS

The Economic Impact of Crude Oil Pipeline Construction and Operation

Consulting Report

ECR | Private Report

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THE ECONOMIC IMPACT OF CRUDE OIL PIPELINE CONSTRUCTION AND OPERATION

The rapid increase in domestic oil production is reshaping the UNITED STATES economy and redefining America's competitive advantages within the global economy, especially within the manufacturing sector. Beyond exploration and production companies, many firms across a diverse set of industry sectors are beneficiaries of billions of dollars in capital expenditures and operation and maintenance expenditures made annually across the hydrocarbon value chain. Pipelines create jobs across the construction and manufacturing supply chain and create significant economic value.

The objectives of this study are to:

- Describe the mix of goods and services used in constructing and operating oil pipelines, with a specific emphasis on those provided by the manufacturing sector
- Present unit cost estimates (i.e., dollars per mile) to build and operate typically-sized crude oil pipelines, and
- Estimate the total economic impacts to the US economy of projected construction and operation of crude oil pipelines constructed in 2015.

IHS estimates that approximately $11.57 billion was spent in the United States to construct the 6,805 miles of new crude oil transmission pipelines that we estimate were commissioned and began operating in 2015. A total of $1.1 billion will then be spent to operate and maintain them during their first year of operation. We continually monitor the status of major crude oil and natural gas pipeline projects across the country, so the expenditure figure is based on actual data. The projected construction spending would create a temporary increase in US employment of 164,111 jobs in 2015, of which 13.3 percent would occur in the manufacturing sector. Similarly, the proposed new pipeline construction spending is expected to contribute $15.5 billion to total US gross domestic product (GDP), with just above 19 percent of the contribution flowing to the manufacturing sector. We expect an increase of $10.2 billion to labor income in 2015, with 16.7 percent occurring in the manufacturing sector.[1] Similarly, the first full year of O&M spending for these pipelines will generate a total increase of 13,066 jobs and increase in GDP of $1.9 billion. The share of the employment increase occurring in the manufacturing sector due to the annual O&M spending is lower, at 4.5%, than during construction because capital expenditure are lower.

Inputs Used in Pipeline Construction and Operation

The first step in estimating the economic impacts of crude oil pipelines is to identify the mix of goods and services, or intermediate inputs, used in their construction and operation. The types of intermediate inputs, and their purchase from the economic sectors that provide them, are known as backward linkages. The total increase in economic activity produced via backward linkages (i.e., the indirect multiplier effect) depends on the types of intermediate inputs required and the extent to which they can be purchased from within a regional economy. The economic impacts will be presented as total changes in economic activity as indicated by such variables as employment, gross domestic product, output and labor income.

IHS's approach for estimating pipeline capital and operating costs included several tasks summarized below. First, IHS analyzed data[2] on the existing mileage of onshore crude oil pipelines in 2014 by

[1] The share of the total US economic impacts occurring in the manufacturing sector is lowest for employment because of the sector's high level of worker productivity (i.e., high values of output and GDP per worker) and its above-average wage levels.

[2] U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, August 2015, "Distribution, Transmission & Gathering, LNG, and Liquid Annual Data".
http://phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=a872dfa122a1d110VgnVCM1000009ed07898CRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print

nominal diameter to determine the most frequent diameters of crude oil transmission pipelines. Based on this analysis, IHS then selected two diameters—12 -inches and 20 -inches—to represent typical crude oil pipelines. Current design and performance standards were established for the two typical pipelines by IHS.

Construction and operation costs for crude oil pipelines vary based on a number of factors, including the following:

- Nominal diameter
- Length
- Depth of soil cover
- Volumetric flow and operating pressure
- Spacing and capacity of pumping stations
- Physical and environmental conditions along the right-of-way, especially terrain and soils
- Climate
- Types of land uses in and adjacent to the ROW
- Number of crossings required for rivers, highways, railroads, etc.
- Costs for obtaining permits, engineering design fees, insurance and other services

ROW acquisition costs are not typically major components of the total cost of a pipeline, generally ranging between 5 percent and 7 percent of total costs.[3] The cost of acquiring ROW is not considered in this analysis as it is difficult to estimate and varies widely from project to project. The local economic impacts of ROW acquisition expenditures can differ in magnitude and timing from those of local purchases of construction materials and payment of wages, depending on where the payment flows and when and how the landowner spends the proceeds.

Once the design assumptions were finalized, IHS then used publicly available pipeline cost information from historical and proposed crude oil pipeline projects along with its proprietary estimating tool, IHS QUE$TOR™ software, to produce a detailed breakdown of capital and operation costs for typical crude oil pipelines. A description of IHS QUE$TOR™ is provided in Appendix C. Average price levels for United States were assumed and cost information is presented in 2015 dollars. As a result, the capital and operating costs presented below for typical crude oil pipelines are based on actual project information as compiled by IHS.

Length of Onshore Crude Oil Pipelines, by State, in 2014

State	Miles of Pipeline
Texas	16,788
Oklahoma	5,844
Wyoming	3,765
California	3,687
Kansas	3,478
Louisiana	3,200
North Dakota	2,818
Minnesota	2,659
Illinois	2,575
Montana	2,380
Missouri	1,847
Michigan	1,437
New Mexico	1,372
Mississippi	1,306
Wisconsin	1,181
Alaska	1,109
Nebraska	758
Colorado	715
Ohio	552
Kentucky	550
All Other States	3,360
Total U.S. Length	61,379

U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, 2015, Distribution, Transmission & Gathering, LNG, and Liquid Annual Data. <http://phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=a872dfa122a1d110VgnVCM1000009ed07898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print>

Crude Oil Pipeline System

Crude oil transmission pipelines convey crude oil from production locations, such as conventional crude oil deposits and shale formations containing tight oil, to processing locations, such as refineries. From there, specialty pipelines carry the refined products to customers, including manufacturers that use refined products as an intermediate input, and final consumers.

[3] Pipeline Equities, September 2010, "Methods for Determining the Value of Pipelines, Part 1." http://www.pipelineequities.com/methods-determining-value-of-pipelines-pt1.php

There were 61,379 miles of onshore crude oil pipelines in the United States in 2014, about 68.6 percent of which were defined as interstate lines. Onshore crude oil pipelines are located in 35 states, but almost 95 percent of the total mileage is concentrated in the 20 states listed in the table above.

As the accompanying table shows, most of the recently completed (i.e., since 2009) and proposed major crude oil pipeline projects often begin in states where high levels of unconventional oil production is occurring. Such locations include the Eagle Ford shale formation in Texas, the Bakken shale formation in North Dakota and Montana, the Haynesville shale play in Texas and Louisiana, the Permian Basin in Texas, the Powder River Basin in Wyoming and the Marcellus and Utica shale formations in eastern Ohio and western Pennsylvania. Existing and proposed projects are located in 26 states, and the accompanying table shows the top 10 states based on distance.

Major Crude Oil Pipeline Projects, Top 10 States, In-service Date 2009-2019

	Existing Projects			Proposed Projects		
Destination State	# of Projects	Capacity (1,000s of Barrels per Day)	Distance in Miles	# of Projects	Capacity (1,000s of Barrels per Day)	Distance in Miles
Texas	103	14,795	17,650	6	820	1,254
Oklahoma	21	2,920	9,383	6	1,000	2,202
Illinois	16	6,256	7,871	2	575	2,032
Wyoming	12	846	2,888			
Montana	9	580	1,785	1	100	-
North Dakota	8	639	417			
Louisiana	4	2,095	935	3	600	1,550
Ohio	3	548	470	3	240	249
Minnesota	5	892	2,434	1	225	380
California	3	547	832	2	390	1,121
U.S. Totals	**211**	**35,270**	**53,168**	**29**	**5,985**	**11,070**

Source: IHS Energy, 2015.

Notes: Rankings based on mileage. Forecasted in-service dates range from 2010 to 2018.

These projects bring the crude oil to strategic hubs for refining. For example, the 600-mile long-Sandpiper pipeline will carry crude oil from the Bakken formation to Superior, Wisconsin; existing pipelines will convey the oil south from there to several refineries located near Chicago. Illinois is also a transfer point where crude oil is shipped south to the US Gulf Coast, or east to major East Coast refineries in the New York and Philadelphia metropolitan areas.

Capital and operation costs are fairly standard across regions but can vary somewhat based on conditions along the ROW. For example, in mountainous regions the number and capacity of pumping stations will be higher to move the crude oil vertically. Similarly, building through densely populated regions will result in additional costs for crossings of linear transportation infrastructure, such as highways, railroads and other pipelines.

The costs for capital equipment used in crude oil pipelines, such as steel pipe, coatings, equipment, pumps, etc., are similar across the United States for most pipeline projects at the factory or the point of production. Similarities in costs also occur as there may be only a small number of manufacturers of the specialized equipment across the United States. However, the delivered costs of components will vary based on the distance to the construction site and the transport mode used. Typically, companies that design and build crude oil and refined petroleum pipelines have the experience and capability to work under the local construction regulations and labor laws and can smoothly work with the applicable government agencies and labor organizations. These companies provide planning, engineering, construction and project management services utilizing their fleet of specialty construction equipment on a country-wide basis.

One of the largest potential sources for regional variations in the cost of building crude oil pipelines is labor. Companies that build crude oil pipelines will first hire local workers with the required skills, thus paying local, market-based wage rates. IHS examined state-level median wage data from the Bureau of Labor Statistics[4] for 2014 to determine the extent to which wage levels varied across the United States. We used 25 occupations that we had identified in other recent energy projects as being essential in the construction of oil pipelines. Our analysis showed that the median wage level for an identical set of construction labor inputs could vary by almost 35 percent across the UNITED STATES, with highest levels in Middle Atlantic, Pacific and New England census divisions. We also analyzed wage levels in

[4] Bureau of Labor Statistics, 2015, Occupational Employment Statistics in 2014 for the United States and Selected States.

five representative states. In Colorado and Massachusetts wage levels were 5.3 percent and 22 percent above the US figure, while they were 3 percent lower in Arizona, 5.4 percent lower in Virginia and 9 percent lower in Michigan. The wage levels used our analysis are not based only on construction occupations, but also include other occupations such as surveyors, engineers, construction managers, truck drivers, geologists, environmental scientists, and machinery mechanics that are needed to install a pipeline.

Construction and Operating Costs for Typical Crude Oil Pipelines

IHS identified typical crude oil pipeline characteristics using current and historical pipeline construction trends and national statistics on pipeline characteristics published by the PHMSA. We also used actual detailed construction data for the approximately 240 recent and proposed pipelines that form the basis for the table of major crude oil pipeline projects by state presented above. Pipeline capital costs were developed for a range of diameters, expressed on a unit basis as the cost per diameter -inch, to provide high- and low-cost estimates. For the two diameters representing typical crude oil pipeline sizes, additional design assumptions were then made about terrain–assumed to be level, distance, number and spacing of pump stations, construction methods, coatings, etc.-to derive costs on a unit distance basis, or the construction cost per mile. As mentioned earlier, the construction costs do not include the cost of acquiring ROW as it is highly project-specific.

Costs for 12-inch diameter crude oil pipeline were based upon an assumed capacity of 70,000 barrels per day, and a length of 200 miles, while the corresponding assumptions for the 20-inch diameter pipeline were 300,000 barrels per day and a length of 450 miles. Both sizes of pipelines were assumed to be built on level terrain. The length and capacity assumptions for the two pipeline sizes were based on modal characteristics of recently completed projects with these diameters. Larger pipelines are more likely to be built over longer distances and our pipeline length assumptions took this fact into consideration. Level terrain was assumed for the crude oil pipelines to provide a cost comparison based solely on differences in diameter. Unit construction costs will be higher if pipelines are constructed in areas with steep terrain as the pipeline will be longer, more hours of construction labor will be required, and additional pump stations will be needed.

Capital costs, which include equipment and materials, account for 35.3 percent and 40.9 percent of the total cost of constructing the two sizes, equivalent to $548,000 and $763,000 per mile. The capital components with the largest cost shares are line pipe and equipment account for 23.8 percent and 27.2 percent respectively of the total unit cost for the two diameters.

The construction cost figures include labor (i.e., wages and fringe benefits) and comprise 30.9 percent and 30.2 percent respectively of the total cost for the 12-inch and 20-inch lines. The total unit construction costs are $1,551,000 per mile for the 12-inch diameter crude oil pipeline and $1,867,000 for the 20-inch diameter crude oil pipeline.

IHS estimated that the annual operation and maintenance (O&M) expenditures for newly constructed crude oil transmission pipelines are $136,000/mile and $175,000/mile for the two sizes in the first few years of their operation. Given the large aggregate distance of the pipelines to be operated and maintained, and the types of activities performed, the bulk of the annual O&M expenditures are composed of logistics and consumables–61.9 percent and 66.1 percent for the two diameters, and operating labor–21.3 percent and 16.5 percent respectively.

The annual O&M costs presented above are only for newly constructed 6,805 miles of crude oil transmission line projects that are initially operated on a stand-alone basis. These annual O&M costs, and their accompanying economic impacts presented below, will occur during first few years of operating newly constructed pipelines. After that time, the annual O&M costs per mile will decrease as the new

pipelines are fully integrated into the existing crude oil pipeline system. Network effects and economies of scale will be captured, so that the unit O&M costs will gradually decline.

IHS also estimated of the US impacts of operating and maintaining the existing network of 61,379 miles of crude oil transmission lines. As noted above, annual unit O&M costs for newly constructed crude oil pipeline projects declines substantially over time as they become fully integrated into the existing pipeline network. The duration and magnitude of the decline will vary by project depending on such factors as: right-of-way conditions including accessibility by maintenance crews and equipment, changes in elevation, diameter and flow volume, capacity utilization, type of adjacent land use (e.g., rural, suburban, and urban), placement above or below ground, depreciation, climate, etc. IHS' experience suggests that over time the annual long-term unit O&M costs for crude oil transmission pipelines will decline to approximately one-third of the level for newly constructed projects. In 2015, existing crude oil transmission pipelines will comprise about 90% of the total network of pipelines when the 6,805 miles of new pipelines are included. While the unit O&M costs for existing crude oil pipelines is substantially lower than for newly constructed pipelines, the aggregate O&M spending for the existing pipelines will be more than twice as high because nine times more pipeline mileage will need to be maintained after 2015.

United States Economic Impacts of Pipeline Construction

IHS estimates that approximately $11.57 billion was spent in the United States in 2015 to construct the 6,805 miles of proposed new crude oil transmission pipelines. The accompanying table shows that the projected construction spending would create a temporary increase in employment of 164,111 jobs, of which 13.3 percent is expected to occur in the manufacturing sector. Similarly, the proposed spending is expected to contribute $15.6 billion to total US gross domestic product (GDP), with just above 19 percent of the contribution flowing to the manufacturing sector. We expect a contribution of $10.2 billion to labor income in 2015, with 16.7 percent occurring in the manufacturing sector. The share of the total US economic impacts occurring in the manufacturing sector is lowest for employment because of the sector's high level of worker productivity (i.e., high values of output and GDP per worker) and its above-average wage levels. The high wage levels result in the 19.1 percent of labor income occurring in the manufacturing sector.

U.S. Economic Impacts of Construction Spending for Crude Oil Pipelines in 2015

Impact Measure	Total Change in Economic Activity	% in the Mfg. Sector	Impact/$1 Billion of Construction Spending
Employment (Number of Jobs)	164,111	13.3%	14,185.8
Direct	55,136	17.6%	4,766.0
Indirect	47,260	19.7%	4,085.2
Induced	61,714	4.5%	5,334.6
Labor Income (Millions of US$)	$ 10,250.3	16.7%	$ 886.0
Direct	$ 3,819.1	20.2%	$ 330.1
Indirect	$ 3,265.1	22.1%	$ 282.2
Induced	$ 3,166.1	6.8%	$ 273.7
Output (Millions of US$)	$ 32,267.9	31.9%	$ 2,789.3
Direct	$ 11,602.4	31.0%	$ 1,002.9
Indirect	$ 10,990.3	44.7%	$ 950.0
Induced	$ 9,675.1	18.3%	$ 836.3
Contribution to GDP (Million of US$)	$ 15,584.1	19.1%	$ 1,347.1
Direct	$ 4,641.0	26.0%	$ 401.2
Indirect	$ 5,283.6	25.5%	$ 456.7
Induced	$ 5,659.5	8.2%	$ 489.2

Note: The total construction spending figure used to derive the impacts was $11.57 billion.

Source: IHS, 2015

The table shows that a total of 24.1 jobs per mile would be created in the UNITED STATES from crude oil pipeline construction, including 3.2 manufacturing jobs per mile.

A primary focus of this study is to measure how the construction of crude oil pipelines affects the manufacturing sector. The shares of economic benefits flowing to the manufacturing sector from the construction of the 20-inch pipeline are slightly higher than for the 12-inch pipeline because expensive capital equipment, such as steel pipe, pumps, and other equipment comprise a higher share of the unit cost of the 20-inch pipeline. As a point of comparison, from 25 percent and 40 percent of the total increases in statewide economic activity from construction spending, depending on the variable, occur in the

construction sector. The increases in statewide economic activity from building a 20-inch diameter pipeline are slightly lower than for the 12-inch line due to economies of scale that occur when building a larger pipeline, and because a higher share of inputs for the smaller pipeline can usually be purchased from within the host state. There is very little difference in the amount of labor required to dig a trench for a 12-inch diameter pipeline and the amount needed for a 20-inch line, so building a smaller diameter pipeline is slightly more labor intensive as noted above.

IHS estimated the total US economic impacts by four-digit NAICS code sub-sector within manufacturing. Appendix A presents the economic contribution in each of the 86 4-digit sub-sectors generated by the construction of new crude oil pipelines in 2015, while Appendix B presents the contributions for new pipeline construction in 2016. While both appendices show that all of the manufacturing sub-sectors will benefit to some extent, between 65 percent and 70 percent of the economic contribution, depending on the impact measure, will occur in the following 11 sub-sectors:

- 3241 Petroleum and Coal Produts
- 3251 Basic Chemicals
- 3255 Paint, Coating, and Adhesives
- 3261 Plastic Products
- 3273 Cement and Concrete Products
- 3311 Iron and Steel Mills
- 3323 Architectural and Structural Metals
- 3327 Machine Shops, Turned products, Screw, Nuts, and Bolts
- 3329 Other Fabricated Metal Products
- 3331 Agriculture, Construction, and Mining Machinery
- 3339 Other Machinery

The total US economic impacts presented above, and in more detail in the tables that follow below, are the sum of the direct spending, the indirect multiplier effect and the induced multiplier effect.

United States Economic Impacts of Pipeline Operation and Maintenance

The section below presents the annual economic impacts on the US economy of maintaining and operating both the existing network of crude oil transmission lines that existed in 2014, and the new pipelines that we projected would be completed in 2015. The economic impacts of operating and maintaining the existing network is presented for 2015, while those for the newly constructed lines will occur during the first year of operation in 2016. In contrast to construction spending, annual O&M spending generates permanent increases in the level of economic activity that extend over the life of the pipelines. Manufactured goods such as steel, pumps, instruments, machinery and equipment etc. will purchased on a periodic basis to replace worn out components and for repairs.

Operating Existing Crude Oil Transmission Pipelines

As noted above, in 2014 there was a total of 61,379 miles of on-shore crude oil transmission pipelines located in the US. We used a conservative estimate of annual unit O&M costs for existing crude oil pipelines, so the permanent economic impacts are very likely to be higher than those presented in the table below. We estimate that the annual O&M spending for the existing network of crude oil transmission pipelines was approximately $2.28 billion in 2015, more than twice as high as annual O&M spending for the newly constructed pipelines. Based on this level of spending, IHS derived the total US economic impacts presented in the accompanying table.

Annual O&M spending on the existing pipeline network in 2015 would produce an increase in US employment of 26,611 jobs, including 1,189 in manufacturing, accompanied by an increase in gross domestic product of just over $3.7 billion. The impact on the manufacturing sector from crude oil pipeline O&M spending is lower than for construction spending as the value of goods needed from the

manufacturing sector will be much smaller. Manufactured goods are more likely to be purchased or leased by the firms operating and maintaining the crude oil pipeline system, so a portion of the increase in demand for manufacturing inputs will be indirect.

US Economic Impacts of Operation & Maintenance Spending for Existing Crude Oil Transmission Lines in 2015				
Impact Measure		**Total Change in Economic Activity**	**% in the Mfg. Sector**	**Impact per Mile**
Employment (# of Jobs)		26,611	4.5%	0.43
Direct		4,410	0.0%	0.07
Indirect		5,984	7.6%	0.10
Induced		16,217	4.5%	0.26
Labor Income (Millions of US$)	$	2,760.0	3.5%	0.04
Direct	$	1,516.2	0.0%	0.02
Indirect	$	398.4	10.0%	0.01
Induced	$	845.4	6.8%	0.01
Output (Millions of US$)	$	6,163.2	14.3%	0.10
Direct	$	2,279.6	0.0%	0.04
Indirect	$	1,300.4	32.2%	0.02
Induced	$	2,583.2	17.9%	0.04
Contribution to GDP (Millions of US$)	$	3,745.2	6.3%	0.06
Direct	$	1,555.1	0.0%	0.03
Indirect	$	680.5	16.3%	0.01
Induced	$	1,509.6	8.2%	0.02

Note 1: Assumes a total of 61,379 miles of pipeline operated in 2015.

Note 2: The absence of direct effects in the mfg. sector is because the direct spending would occur outside it, primarily in the pipeline transportation sector. As result, the increases in economic activity in the mfg. are generated by the indirect purchases.

Operating Newly Built Crude Oil Transmission Pipelines

Based on the unit O&M costs presented above for newly constructed crude oil transmission lines, the total annual O&M spending for the 6,805 miles of new projects during their first full year of operation in 2016 is estimated to be approximately $1.12 billion. IHS estimated the total US economic impacts from this annual, which are presented in the accompanying table

Based on the unit costs presented above, the total annual O&M spending for the newly constructed pipelines during their first full year of operation is estimated to be approximately $1.12 billion. IHS estimated the total US economic impacts from this annual, which are presented in the accompanying table.

We estimate that the total increase in US employment would be 13,066 jobs, including 584 in manufacturing, and an increase in gross domestic product of just under $1.9 billion. In contrast to construction spending, the share of the total increase in labor income in the manufacturing sector from annual O&M spending is only 3.5 percent due to indirect nature of the demand for manufactured goods,

and the high wages paid to skilled, non-manufacturing workers that will operate and maintain the pipelines.

A comparison of the construction and O&M economic impacts per $1 million in direct spending shows that the latter generates fewer jobs, but more labor income, suggesting that the annual wage levels of workers operating and maintaining crude oil pipelines is higher than for workers building them. O&M spending generates an increase of only .52 manufacturing jobs per $1 million in direct spending versus the much higher level of 1.9 manufacturing jobs per $1 million in construction spending due to the high value of purchases of steel, equipment, machinery, etc., during construction.

US Economic Impacts of O&M Spending for Newly Built Crude Oil Transmission Lines in 2016

Impact Measure	Total Economic Contribution	% in the Mfg. Sector	Impact per Mile
Employment (# of jobs)	13,066	4.5%	1.9
Direct	2,156	0.0%	0.3
Indirect	2,941	7.6%	0.4
Induced	7,969	4.5%	1.2
Labor Income (Millions of US$)	$ 1,384.5	3.5%	0.2
Direct	$ 760.6	0.0%	0.1
Indirect	$ 199.8	10.0%	0.0
Induced	$ 424.1	6.8%	0.1
Output (Millions of US$)	$ 3,054.5	14.4%	0.4
Direct	$ 1,105.3	0.0%	0.2
Indirect	$ 652.7	32.1%	0.1
Induced	$ 1,296.5	17.8%	0.2
Contribution to GDP (Millions of US$	$ 1,878.6	6.3%	0.3
Direct	$ 780.1	0.0%	0.1
Indirect	$ 341.3	16.3%	0.1
Induced	$ 757.2	8.2%	0.1

Note: The economic impacts above will occur during 2016, the first full year of operating the 6,805 miles of new crude oil transmission pipelines IHS projects were commissioned and began operating in 2015. The figures above are presented in 2015$.

Annual O&M spending generates permanent increases in state and local economic activity, such as employment and value added, as the crude oil pipeline system has to be continually operated and maintained. At the state and local levels, the economic multiplier effects of O&M spending are usually comparable to or slightly higher than during construction as higher shares of inputs, including labor, maintenance and repair services, supplies, etc., are purchased locally. Finally, the "per mile " economic impacts of O&M spending shown in the accompanying table are much lower than the "per miles" economic impacts for construction as spending is divided across approximately nine times more pipeline miles, demonstrating economies of scale.

Annual Impacts of Crude Oil Pipeline Construction and Operation

The total contribution to the US economy of crude oil transmission pipeline construction and operation in a single year of the sum of three direct spending effects:

- Construction of new pipelines; as noted above of 6,805 miles of new pipeline in 2015, increased total US employment by 164,111 jobs
- Operation and maintenance spending for the existing crude oil pipeline system (i.e., the 61,379 miles of on-shore pipeline that was in operation at the end of 2014), and
- Operation and maintenance spending for newly constructed pipelines; as we described above unit O&M spending for newly built crude oil pipeline is high during the first several years of operation and then declines over time as new projects are incorporated in the existing network.

IHS estimated the total annual contributions to the US economy produced by the three direct spending effects described above for both 2015 and 2016. The results of our analysis are presented in the accompanying table. Total direct spending in 2016 will be about 16.7% higher than in 2015 primarily because the construction costs for the projected 6,447 miles of new pipeline would be almost $2.5 billion greater; while total O&M costs for the existing system would increase as the new projects completed before 2015 are incorporated into the existing system. Project-specific capital cost figures compiled by IHS showed that the pipelines built in 2016 will have substantially higher unit costs than in 2015.

According to IHS' energy experts, the recent sharp decline in the price of crude has not yet had a significant effect in terms of proposed crude oil pipeline projects being cancelled or delayed. To date, two projects have been cancelled that were scheduled to come online in 2016, and three have been moved to a 2017 start date. However, these cancellations/delays are not necessarily tied to the recent plunge in the crude oil prices, rather they are due to not receiving enough shipper commitment during the open season or other political factors as in the case of Keystone XL. We believe that lower oil prices would delay or cancel any future projects that were planned to begin operating in 2017 or later.

Total Annual Contributions to the U.S. Economy of Crude Oil Pipeline Construction and Operation & Maintenance Spending						
	Total Economic Contribution		% of Contribution in the Manufacturing Sector		Contributionn per $1 Billion of Direct Spending	
Economic Variable	2015	2016	2015	2016	2015	2016
Employment (Number of Jobs)	207,800	243,167	11.4%	11.7%	13,628.2	13,656.1
Direct	62,400	74,235	15.5%	15.8%	4,092.4	4,169.0
Indirect	57,048	67,266	17.6%	17.9%	3,741.4	3,777.6
Induced	88,351	101,666	4.5%	4.5%	5,794.4	5,709.5
Labor Income (Millions of US$)	$ 14,820.0	$ 17,023.6	12.6%	13.2%	$ 971.9	$ 956.0
Direct	$ 6,331.4	$ 7,150.5	12.2%	13.1%	$ 415.2	$ 401.6
Indirect	$ 3,922.7	$ 4,626.6	20.1%	20.4%	$ 257.3	$ 259.8
Induced	$ 4,566.0	$ 5,246.5	6.8%	6.8%	$ 299.5	$ 294.6
Output (Millions of US$)	$ 42,346.0	$ 49,372.0	27.7%	28.2%	$ 2,777.2	$ 2,772.7
Direct	$ 15,261.3	$ 17,832.8	23.6%	24.5%	$ 1,000.9	$ 1,001.5
Indirect	$ 13,131.3	$ 15,506.5	42.6%	43.0%	$ 861.2	$ 870.8
Induced	$ 13,953.4	$ 16,032.7	18.1%	18.2%	$ 915.1	$ 900.4
Contribution to GDP (Millions of $US)	$ 21,756.2	$ 25,135.2	15.4%	15.9%	$ 1,426.8	$ 1,411.6
Direct	$ 7,193.5	$ 8,213.4	16.8%	17.9%	$ 471.8	$ 461.3
Indirect	$ 6,403.5	$ 7,546.2	23.8%	24.1%	$ 420.0	$ 423.8
Induced	$ 8,159.2	$ 9,375.6	8.2%	8.2%	$ 535.1	$ 526.5

Note; the dollar figures above are in 2015$

In 2015 the combined economic contribution from the three direct effects resulted in an increase in total US employment of 207,800 jobs, with 11.4% of them occurring in the Manufacturing sector. Similarly, in 2016 the increase in total US employment would be 243,167 jobs, with 11.7% or 28,438 jobs generated in the Manufacturing sector. The shares of the total US economic contributions in Manufacturing are higher for the other three variables – Labor Income, Output, and GDP - because there would be no direct spending in the Manufacturing from O&M spending; rather the demand for Manufactured inputs for O&M activities will be derived one. On average across the four economic variables shown in the accompanying table, about 75% of the economic contribution to the US economy in 2015 would be due to construction of new pipelines; this share would rise slightly to 78% in 2016. To put the economic contributions shown in the accompanying table in perspective, depending on the variable they account for between 0.12% and 0.17% of total US economic activity in 2015.

The level of pipeline construction spending varies substantially from year to year because of the lumpiness or high costs of individual projects, and uncertainty over how long it may take to obtain the required regulatory approvals before construction can start. This uncertainty is increased by the current sharp decline in crude oil prices which makes it more difficult to economically justify long-term, high-cost investments like pipelines. As result, we expect the annually variability in the total economic contribution to the US economy from crude oil pipeline construction and operation to continue for at least the next five years.

Projections for Continued Growth in Crude Oil Pipeline Spending

United States crude oil production has expanded significantly since 2006[5], rising from 5.1 million barrels per day (b/d) to 5.5 million b/d in 2010 and reaching 8.7 million b/d in 2014. Pipeline capital spending

[5] IHS, November 30 2015, "North American Crude Oil Market Outlook".

grew significantly over this eight year period to support US upstream oil activity and production plans. US oil and natural gas transmission pipeline project spending increased from approximately $10.1 billion in 2010 to almost $37.4 billion in 2015. The average US onshore crude oil capital spending run rate over this period was approximately $20.5 billion with $14 billion spent on expanding natural gas transmission lines and the balance to crude oil pipelines.

IHS estimates that US production of crude oil peaked at just below 9.7 million b/d in April of 2015 before falling sharply to 8.8 million b/d by February 2016. Our February 2016 forecast calls for U.S crude production to continue declining, reaching a trough of 8.3 million b/d in the summer of 2017 before gradually rising to 8.9 million b/d by the end of that year. Similarly, our February forecast calls for the West Texas Intermediate (WTI) Cushing spot price for crude oil to average $30.58/barrel during the first quarter of 2016, before climbing to $48.63 per barrel by the fourth quarter of 2017, and then to $77 per barrel in 2020. Pipeline project spending was underpinned by the upstream production plans established in prior periods. While the rate of capacity additions will likely slow over the short term, additions will still be needed over the medium to long term to meet our view of supply and demand fundamentals. IHS expects US crude oil production will continue growing slowly after 2017 in order to meet demand, approaching a production rate of 10 million b/d in 2020. Correspondingly US major crude oil capital project spending in the coming years will be comparable to history. US onshore oil transmission pipeline capital spending is expected to have an annual run rate of $11.5 billion between 2016 and 2018 as both markets rebalance and then resume growth.

Appendix A

U.S. Economic Impacts of Crude Oil Pipeline Construction in 2015 by Four-Digit Mfg. sector

NAICS Code and Description	Employment	Labor Income (Millions of US$)	Output (Millions of US$)	Contribution to GDP (Millions of US$)
3111 Animal Food Manufacturing	28	$ 2.2	$ 40.5	$ 6.3
3112 Grain and Oilseed Manufacturing	29	$ 2.7	$ 59.6	$ 7.4
3113 Sugar and Products Manufacturing	35	$ 2.3	$ 19.7	$ 4.2
3114 Fruit and Vegetable Preserving	90	$ 5.4	$ 40.7	$ 8.5
3115 Dairy Product Manufacturing	70	$ 5.1	$ 73.9	$ 9.7
3116 Animal Slaughtering and Processing	238	$ 10.9	$ 95.2	$ 12.9
3117 Seafood Product Preparation	21	$ 1.2	$ 8.1	$ 1.3
3118 Bakeries and Tortilla Manufacturing	151	$ 7.5	$ 37.6	$ 10.7
3119 Other Food Manufacturing	89	$ 6.6	$ 70.8	$ 21.8
3121 Beverage Manufacturing	103	$ 9.1	$ 84.7	$ 23.6
3122 Tobacco Manufacturing	7	$ 1.0	$ 21.8	$ 14.6
3131 Fiber, Yarn, and Thread Mills	12	$ 0.5	$ 4.3	$ 0.7
3132 Fabric Mills	22	$ 1.2	$ 7.4	$ 1.8
3133 Textile and Fabric Mills	19	$ 1.0	$ 5.5	$ 1.3
3141 Textile Furnishings Mills	32	$ 1.5	$ 8.4	$ 2.1
3149 Other Textile Product Mills	49	$ 2.1	$ 7.7	$ 2.6
3151 Apparel Knitting Mills	9	$ 0.3	$ 1.1	$ 0.4
3152 Cut and Sew Apparel Manufacturing	86	$ 3.6	$ 11.6	$ 4.3
3159 Accessories and Other Apparel Mfg.	5	$ 0.2	$ 0.9	$ 0.3
3161 Leather and Hide Finishing	1	$ 0.1	$ 0.5	$ 0.1
3162 Footwear Manufacturing	6	$ 0.3	$ 1.1	$ 0.4
3169 Other Leather Products	5	$ 0.2	$ 1.0	$ 0.3
3211 Sawmills and Wood Preservation	192	$ 10.1	$ 52.2	$ 11.9
3212 Plywood and Engineered Wood Mfg.	138	$ 7.3	$ 32.7	$ 11.2
3219 Other Wood Manufacturing	370	$ 17.8	$ 64.8	$ 21.1
3221 Pulp, Paper and Paperboard Mills	71	$ 7.9	$ 61.8	$ 17.2
3222 Converted Paper Products	211	$ 17.0	$ 96.2	$ 25.2
3231 Support Activities (Printing)	324	$ 17.7	$ 55.0	$ 20.0
3241 Petroleum and Coal Prod. Mfg.	211	$ 49.8	$ 1,101.8	$ 335.5
3251 Basic Chemical Mfg.	169	$ 24.0	$ 484.8	$ 66.2
3252 Resin, Rubber, and Fiber Mfg.	83	$ 10.9	$ 127.9	$ 18.1
3253 Agricultural Chemical Mfg.	31	$ 3.6	$ 50.9	$ 7.7
3254 Pharmaceutical and Medicine Mfg.	118	$ 20.8	$ 164.2	$ 54.5
3255 Paint, Coating, and Adhesive Mfg.	834	$ 89.2	$ 652.9	$ 135.9
3256 Soap, Cleaning, and Toiletry Mfg.	51	$ 5.1	$ 61.0	$ 19.5
3259 Other Chemical Product Mfg.	63	$ 6.5	$ 41.4	$ 9.4
3261 Plastic Product Mfg.	594	$ 38.9	$ 209.3	$ 67.1
3262 Rubber Product Mfg.	121	$ 8.6	$ 46.1	$ 15.4
3271 Clay Product and Refractory Mfg.	73	$ 4.7	$ 15.0	$ 6.2
3272 Glass and Glass Product	53	$ 3.7	$ 15.8	$ 5.5
3273 Cement and Concrete Products	755	$ 49.0	$ 206.6	$ 67.0
3274 Lime and Gypsum Products	34	$ 2.7	$ 16.8	$ 4.9
3279 Other Nonmetallic Mineral Products	183	$ 12.0	$ 62.9	$ 21.9

U.S. Economic Impacts of Crude Oil Pipeline Construction in 2015 by Four-Digit Mfg. sector

NAICS Code and Description	Employment	Labor Income (Millions of US$)	Output (Millions of US$)	Contribution to GDP (Millions of US$)
3311 Iron and Steel Mills	360	$ 38.4	$ 454.6	$ 62.2
3312 Steel Product Mfg. From Purchases	222	$ 18.4	$ 174.1	$ 23.9
3313 Alumina and Aluminum Production	64	$ 5.4	$ 49.7	$ 6.8
3314 Other Nonferrous Metal Production	94	$ 7.9	$ 121.1	$ 12.9
3315 Foundries	342	$ 24.5	$ 97.8	$ 28.7
3321 Forging and Stamping	203	$ 15.9	$ 88.3	$ 23.1
3322 Cutlery and Handtool Mfg.	38	$ 3.0	$ 10.5	$ 4.5
3323 Architectural and Structural Mfg.	1,139	$ 75.0	$ 304.0	$ 100.0
3324 Boiler, Tank and Container Mfg.	192	$ 14.8	$ 79.9	$ 23.0
3325 Hardware Manufacturing	17	$ 1.3	$ 5.8	$ 2.1
3326 Spring and Wire Product Mfg.	89	$ 5.6	$ 23.2	$ 8.7
3327 Machine Shops Mfg.	729	$ 48.8	$ 136.8	$ 60.8
3328 Coating, Engraving, and Heat Metals	302	$ 18.2	$ 74.7	$ 27.0
3329 Other Fabricated Metal Products	8,662	$ 643.8	$ 2,447.6	$ 893.4
3331 Ag., Construction, and Mining Machinery	560	$ 57.8	$ 584.6	$ 158.5
3332 Industrial Machinery Mfg.	28	$ 2.4	$ 11.6	$ 4.1
3333 Commercial and Service Industrial Machinery	76	$ 6.1	$ 35.4	$ 12.5
3334 HVAC and Commercial Refrig. Equipment	136	$ 9.2	$ 39.5	$ 14.3
3335 Metalworking Machinery	82	$ 6.0	$ 16.7	$ 7.9
3336 Turbine and Power Transmission Equip.	76	$ 7.3	$ 60.7	$ 15.7
3339 Other Machinery Mfg.	976	$ 88.8	$ 452.3	$ 156.5
3341 Computer and Peripheral Eq. Mfg.	35	$ 6.3	$ 40.6	$ 12.4
3342 Communications Eq. Mfg.	64	$ 7.2	$ 30.8	$ 10.9
3343 Audio and Video Eq. Mfg.	7	$ 0.7	$ 3.7	$ 0.9
3344 Semiconductor and Comp. Mfg.	217	$ 23.9	$ 169.4	$ 76.1
3345 Electronic Instrument Mfg.	60	$ 5.9	$ 23.4	$ 9.1
3346 Magnetic Media Mfg.	9	$ 1.2	$ 4.9	$ 1.8
3351 Electric Lighting Eq. Mfg.	89	$ 7.6	$ 32.4	$ 10.6
3352 Household Appliance Mfg.	29	$ 2.4	$ 16.0	$ 4.1
3353 Electrical Equipment	151	$ 14.0	$ 63.1	$ 21.1
3359 Other Electrical Eq. and Comp. Mfg.	125	$ 10.9	$ 55.5	$ 17.4
3361 Motor Vehicle Mfg.	39	$ 4.4	$ 76.3	$ 6.5
3362 Motor Vehicle Body and Trailer Mfg.	39	$ 2.4	$ 12.3	$ 2.4
3363 Motor Vehicle Parts Mfg.	242	$ 18.2	$ 128.1	$ 18.7
3364 Aerospace Product and Parts Mfg.	16	$ 1.9	$ 7.6	$ 2.1
3365 Railroad Rolling Mfg.	11	$ 1.0	$ 6.3	$ 1.2
3366 Ship and Boat Building	14	$ 0.9	$ 3.8	$ 1.0
3369 Other Transportation Eq. Mfg.	12	$ 0.9	$ 8.7	$ 1.4
3371 Household and Institutional Furniture Mfg.	138	$ 6.6	$ 24.4	$ 9.7
3372 Office Furniture and Fixtures Mfg.	17	$ 1.0	$ 4.5	$ 1.7
3379 Other Furniture-Related Mfg.	18	$ 1.0	$ 5.3	$ 1.9
3391 Medical Eq. and Supplies Mfg.	108	$ 9.0	$ 28.4	$ 17.9
3399 Other Misc. Mfg.	179	$ 12.5	$ 41.1	$ 20.7
Total Impact in Manufacturing	**21,795**	**$ 1,711.1**	**$ 10,278.0**	**$ 2,972.9**

Note: The total construction spending figure used to derive the impacts was $11.57 billion to construct 6,805 miles of new pipeline.

Source: IHS, 2016

Appendix B

U.S. Economic Impacts of Crude Oil Pipeline Construction in 2016 by Four-Digit Mfg. Sub-sector

NAICS Code and Description	Employment	Labor Income (Millions of US$)	Output (Millions of US$)	Contribution to GDP (Millions of US$)
3111 Animal Food	34	$ 2.7	$ 49.2	$ 7.6
3112 Grain and Oilseed	36	$ 3.3	$ 72.4	$ 9.0
3113 Sugar and Products	43	$ 2.8	$ 23.9	$ 5.1
3114 Fruit and Vegetable Preserving	109	$ 6.5	$ 49.4	$ 10.3
3115 Dairy Product	85	$ 6.2	$ 89.7	$ 11.8
3116 Animal Slaughtering and Processing	289	$ 13.2	$ 115.7	$ 15.6
3117 Seafood Product Preparation	26	$ 1.4	$ 9.8	$ 1.6
3118 Bakeries and Tortilla	183	$ 9.1	$ 45.6	$ 13.0
3119 Other Food	108	$ 8.1	$ 86.0	$ 26.4
3121 Beverage	125	$ 11.1	$ 102.9	$ 28.7
3122 Tobacco	8	$ 1.2	$ 26.5	$ 17.8
3131 Fiber, Yarn, and Thread Mills	15	$ 0.6	$ 5.2	$ 0.9
3132 Fabric Mills	27	$ 1.5	$ 9.0	$ 2.1
3133 Textile and Fabric Mills	23	$ 1.3	$ 6.7	$ 1.6
3141 Textile Furnishings Mills	38	$ 1.9	$ 10.2	$ 2.5
3149 Other Textile Product Mills	59	$ 2.6	$ 9.4	$ 3.1
3151 Apparel Knitting Mills	11	$ 0.4	$ 1.3	$ 0.4
3152 Cut and Sew Apparel	105	$ 4.4	$ 14.0	$ 5.2
3159 Accessories and Other Apparel	7	$ 0.3	$ 1.1	$ 0.3
3161 Leather and Hide Finishing	1	$ 0.1	$ 0.7	$ 0.1
3162 Footwear	8	$ 0.4	$ 1.3	$ 0.4
3169 Other Leather Products	7	$ 0.3	$ 1.2	$ 0.4
3211 Sawmills and Wood Preservation	234	$ 12.2	$ 63.5	$ 14.4
3212 Plywood and Engineered Wood	168	$ 8.8	$ 39.7	$ 13.7
3219 Other Wood	450	$ 21.6	$ 78.7	$ 25.6
3221 Pulp, Paper and Paperboard Mills	86	$ 9.6	$ 75.1	$ 20.9
3222 Converted Paper Products	257	$ 20.7	$ 116.9	$ 30.6
3231 Support Activities (Printing)	394	$ 21.5	$ 66.8	$ 24.3
3241 Petroleum and Coal Prod.	256	$ 60.5	$ 1,338.7	$ 407.6
3251 Basic Chemical	205	$ 29.2	$ 589.1	$ 80.4
3252 Resin, Rubber, and Fiber	100	$ 13.2	$ 155.4	$ 22.0
3253 Agricultural Chemical	37	$ 4.4	$ 61.9	$ 9.4
3254 Pharmaceutical and Medicine	143	$ 25.2	$ 199.5	$ 66.3
3255 Paint, Coating, and Adhesive	1,013	$ 108.4	$ 793.3	$ 165.2
3256 Soap, Cleaning, and Toiletry	62	$ 6.3	$ 74.2	$ 23.7
3259 Other Chemical Product	77	$ 7.9	$ 50.3	$ 11.4
3261 Plastic Product	721	$ 47.3	$ 254.3	$ 81.6
3262 Rubber Product	147	$ 10.5	$ 56.0	$ 18.7
3271 Clay Product and Refractory	89	$ 5.7	$ 18.3	$ 7.5
3272 Glass and Glass Product	64	$ 4.5	$ 19.2	$ 6.7
3273 Cement and Concrete Products	917	$ 59.6	$ 251.0	$ 81.4
3274 Lime and Gypsum Products	42	$ 3.3	$ 20.4	$ 6.0
3279 Other Nonmetallic Mineral Products	222	$ 14.6	$ 76.5	$ 26.7

U.S. Economic Impacts of Crude Oil Pipeline Construction in 2016 by Four-Digit Mfg. Sub-sector

NAICS Code and Description	Employment	Labor Income (Millions of US$)	Output (Millions of US$)	Contribution to GDP (Millions of US$)
3311 Iron and Steel Mills	437	$ 46.7	$ 552.4	$ 75.5
3312 Steel Product From Purchases	270	$ 22.4	$ 211.6	$ 29.0
3313 Alumina and Aluminum Production	78	$ 6.5	$ 60.3	$ 8.2
3314 Other Nonferrous Metal Production	114	$ 9.6	$ 147.2	$ 15.7
3315 Foundries	416	$ 29.8	$ 118.9	$ 34.9
3321 Forging and Stamping	246	$ 19.4	$ 107.3	$ 28.0
3322 Cutlery and Handtool	46	$ 3.6	$ 12.7	$ 5.4
3323 Architectural and Structural	1,385	$ 91.1	$ 369.4	$ 121.5
3324 Boiler, Tank and Container	233	$ 18.0	$ 97.1	$ 27.9
3325 Hardware	21	$ 1.6	$ 7.0	$ 2.6
3326 Spring and Wire Product	108	$ 6.9	$ 28.2	$ 10.6
3327 Machine Shops	886	$ 59.3	$ 166.2	$ 73.9
3328 Coating, Engraving, and Heat Metals	367	$ 22.2	$ 90.7	$ 32.9
3329 Other Fabricated Metal Products	10,525	$ 782.2	$ 2,973.7	$ 1,085.4
3331 Ag., Construction, and Mining Machinery	681	$ 70.2	$ 710.3	$ 192.6
3332 Industrial Machinery	34	$ 2.9	$ 14.1	$ 4.9
3333 Commercial & Service Industrial Machinery	92	$ 7.5	$ 43.0	$ 15.2
3334 HVAC and Commercial Refrig. Equipment	165	$ 11.2	$ 48.0	$ 17.4
3335 Metalworking Machinery	100	$ 7.3	$ 20.3	$ 9.6
3336 Turbine and Power Transmission Equip.	92	$ 8.9	$ 73.7	$ 19.0
3339 Other Machinery	1,186	$ 107.8	$ 549.6	$ 190.2
3341 Computer and Peripheral Eq.	42	$ 7.6	$ 49.3	$ 15.0
3342 Communications Eq.	78	$ 8.8	$ 37.5	$ 13.2
3343 Audio and Video Eq.	8	$ 0.8	$ 4.4	$ 1.1
3344 Semiconductor and Comp.	263	$ 29.0	$ 205.8	$ 92.4
3345 Electronic Instrument	73	$ 7.2	$ 28.4	$ 11.1
3346 Magnetic Media	11	$ 1.5	$ 6.0	$ 2.2
3351 Electric Lighting Eq.	108	$ 9.2	$ 39.4	$ 12.9
3352 Household Appliance	36	$ 2.9	$ 19.5	$ 5.0
3353 Electrical Equipment	183	$ 17.0	$ 76.7	$ 25.7
3359 Other Electrical Eq. and Components	152	$ 13.2	$ 67.5	$ 21.1
3361 Motor Vehicle	48	$ 5.3	$ 92.7	$ 8.0
3362 Motor Vehicle Body and Trailer	47	$ 2.9	$ 15.0	$ 2.9
3363 Motor Vehicle Parts	294	$ 22.2	$ 155.7	$ 22.8
3364 Aerospace Product and Parts	20	$ 2.3	$ 9.3	$ 2.5
3365 Railroad Rolling	13	$ 1.2	$ 7.7	$ 1.4
3366 Ship and Boat Building	17	$ 1.1	$ 4.6	$ 1.2
3369 Other Transportation Eq.	15	$ 1.1	$ 10.6	$ 1.7
3371 Hhld.& Institutional Furniture	168	$ 8.1	$ 29.6	$ 11.8
3372 Office Furniture and Fixtures	21	$ 1.2	$ 5.5	$ 2.1
3379 Other Furniture-Related	22	$ 1.2	$ 6.5	$ 2.3
3391 Medical Eq. and Supplies	131	$ 11.0	$ 34.5	$ 21.8
3399 Other Misc.	218	$ 15.2	$ 49.9	$ 25.2
Total Impact in Manufacturing	**26,482**	**$ 2,078.9**	**$ 12,487.6**	**$ 3,612.0**

Note: Total construction spending used to derive the impacts above is $14.06 billion for building 6,447 miles of new pipeline

Source: IHS, 2016

Appendix C

IHS QUE$TOR™ Model

Over the years, IHS has developed and continuously refines a software tool called QUE$TOR that is used for analyzing the costs of new oil and gas projects. It was used to determine the crude oil pipeline construction and operating costs contained in the tables above. The program has recently undergone a complete software rewrite, retaining all the former capabilities but adding a significant increase in speed and functionality. QUE$TOR™ is a project modeling, evaluation and decision-support system for global application in the oil and gas industry. The program enables users to estimate and run sensitivities on the capital and operation expenditures of alternative field development plans. Using detailed technical algorithms and regional databases, QUE$TOR™ provides a consistent methodology for generating cost estimates and optimizing development plans. At the heart of QUE$TOR™ are cost and technical databases (user accessible and customizable) covering all producing regions of the world. These databases are updated every six months with costs gathered from actual projects, fabricators, vendors and service companies. For example, the individual crude oil pipeline projects used to derive the figures presented above in the table summarizing major crude oil project capacities and distances by state are inputs into the QUE$TOR™ database. Using primary input data (recoverable reserves, reservoir depth, and water depth), a production profile is generated, the development concept is defined, and design flowrates are calculated. The program then sizes facilities, pipelines and substructures and calculates capital costs, drilling costs, operating costs and abandonment costs. These costs are then scheduled to provide project cash flows. The regional databases are populated with unit rates for equipment items, materials, fabrication installation, hook-up and commissioning and other project costs. QUE$TOR™ has been benchmarked against actual project costs and is continuously maintained to reflect the latest changes in technology.