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Abstract

The program that we proposed and successfully created is a pipeline cost estimation program. This program takes various user inputs and translates that information into a total estimated cost for the completion of the project.

Introduction

One of the advancements humans have made in recent history is the ability to transport liquids and gases through the use of pipelines. Pipelines decrease both the amount of time and labor it would take to displace a liquid or gas from one destination to another. They have brought convenience to us through indoor plumbing, sewage systems, etc. Not only have they brought us convenience, but they have also helped the economy by creating job opportunities for people to put in a pipeline, make the pipes out of the required materials, the buying/renting of machinery to put in a pipeline, and the contracting to do the job. Our program estimates the cost to put in a pipeline under various conditions. The user has the option to select or input the material used, the length and diameter of the pipeline, the depth of the pipeline, land acquisition percentage, average price per acre, soil composition, the length of time to finish the project, hourly wage per worker, and the season that project is being done in. With these selections, the user is able to acquire the cost per linear foot of the pipe, the total cost of the pipe, the number of workers needed to work on a project, the estimated cost of labor, and the estimated land cost; and with all this an estimated total cost can be obtained.

Method

The costs associated with the installation of a pipeline are influenced by a limitless number of factors. During the development stage of the creation of our program, the main variables influencing the cost were identified and either quantified or qualified.

The first bit of information needed is the type of piping to be used, and the diameter of the pipe. Our program is limited to either steel pipe ranging in diameter from 2" to 8" or fiberglass pipe ranging in diameter from 2" to 12", both diameters in steps of 2". The type of pipe needed depends on the purpose of the pipeline. A low pressure water line, for example, would be run using fiberglass piping due to the low pressure flow and non-corrosive properties. A natural gas line, however, would utilize steel piping. Once the material is identified, the diameter of the piping used depends on the required flow rate, discharge rate, pumps used, or a range of other factors. The material type and diameter is then compared to a list of costs per linear foot of a given piping and used to estimate total cost.

The length and depth of the pipe are fairly obvious inputs. The length of the pipeline is the total path distance from point A to point B. The depth of the line is often outlined in construction codes. Certain types of pipes must be buried a certain depth for safety and planning reasons.

The next set of data needed involves land acquisition, Right of Way, and terrain. State law requires that 15 feet on either side of the pipeline to be purchased. Some of this land must be purchased from the current property owners. The rest of the land is usually state or city-owned, and does not affect the overall cost of the installation. As such, the

percentage of the total Right of Way purchased must be researched and provided. To estimate the purchase price of this percentage of land, the average cost per acre of the surrounding land is required. The final factor dealing with the surrounding land is the type of soil most commonly found. The user has four soil types to choose from, which are sand, silt, clay, and rock, listed in order of increasing difficulty to dig. Installing a pipe 8 feet down in an area where bedrock is 2 feet below the surface is much more difficult than in an area with 10 feet of a sandy soil between the ground and bedrock. A simple test on a soil boring can identify the strata of soil in a given location.

The largest factor, and potentially least predictable factor, is associated labor costs. The three main variables that are required to compute this portion are project length, worker wage, and season of the work; although previous variables, such as terrain type and depth also affect the number of laborers needed. To estimate the number of workers needed, the length and depth of the pipeline, the soil type, and the time span of the project are plugged into a formula that the team derived. This number is then used in another formula involving wage, hours worked per day, and the length of the project. The last bit of information given, the season in which the work is in, relies on seasonal weather patterns to predict delays due to rain, snow, ice, etc. Certain seasons, such as Spring, are more likely to bring out weather that will cause costly delays.

Once all the variables have been researched and collected, the various subtotals are calculated and summed.

Results

The screenshot shows a software window titled "Cost Estimation for Running Pipeline". The interface is organized into several sections:

- Pipeline Variables:** Includes radio buttons for "steel" and "fiberglass", a text input for "Length" with units "feet" and "miles", a text input for "Depth" with the unit "feet", and a dropdown menu for "Diameter" with the unit "inches".
- Land Variables:** Includes text inputs for "Land acquisition" (with a "%" symbol) and "Avg. Price / Acre" (with a "\$" symbol), and a dropdown menu for "Soil composition".
- Labor Variables:** Includes text inputs for "Time schedule" (with "months"), "Hourly wage" (with "\$"), and a dropdown menu for "Season of work".
- Output Fields:** On the right side, there are two stacked text inputs for "Cost per linear foot" and "Total cost of pipe". Below these are two more stacked text inputs for "Number of workers" and "Estimated labor cost". Further down are two more stacked text inputs for "Estimated land cost" and "Estimated Final Cost". The "Estimated Final Cost" field is highlighted in orange.
- Buttons:** At the bottom, there are three buttons: "Compute", "Clear Form", and "Exit".

We attempted to make the GUI as user-friendly as possible. The input variables are sorted by relevance, and are clearly marked. The interface could have easily become convoluted and hard to understand without the use of the combo boxes and clear delineation of variable groups.

Running the Program:

Pipeline Variables	
Material:	<input checked="" type="radio"/> steel <input type="radio"/> fiberglass
Length:	<input type="text" value="1"/>
	<input type="radio"/> feet <input checked="" type="radio"/> miles
Depth:	<input type="text" value="6"/> feet
Diameter:	<input type="text" value="Choose"/> inches
	<input type="text" value="2"/>
	<input type="text" value="4"/>
	<input type="text" value="6"/>
	<input type="text" value="8"/>

Land Variables	
Land acquisition:	<input type="text" value="5"/> %
Avg. Price / Acre:	<input type="text" value="1279"/> \$
Soil composition:	<input type="text" value="Choose"/>
	<input type="text" value="Clay"/>
	<input type="text" value="Sand"/>
	<input type="text" value="Silt"/>
	<input type="text" value="Rock"/>

Labor Variables	
Time schedule:	<input type="text" value="6"/> months
Hourly wage:	<input type="text" value="8.50"/> \$
Season of work:	<input type="text" value="Choose"/>
	<input type="text" value="Long-term"/>
	<input type="text" value="Spring"/>
	<input type="text" value="Summer"/>
	<input type="text" value="Fall"/>
	<input type="text" value="Winter"/>

1. Select the piping material.
2. Input the length of the pipeline in the units marked below.
3. Enter the depth the pipeline will be installed at.
4. Select the required diameter piping.
5. Calculate and enter the percentage of RoW to be purchased.
6. Enter the average cost of land per acre around the site of the dig.
7. Select the type of soil most commonly found near the job site.
8. Input the approximate project length.
9. Enter the hourly wage of a laborer.
10. Select the season in which the majority of the work will take place in or select long-term if the project is several months long.

Conclusions

At the start of this program we had little knowledge of pipelines and assumed they were relatively simple and did not vary much from pipeline to pipeline. This assumption was incorrect. Pipelines can transport any chemically stable substance. This results in a wide variety of pipeline construction methods. Substances moved by pipeline vary from the 800 mile Trans-Alaskan crude oil Pipeline to the 5 km beer pipeline at the Veltins arena, a large soccer stadium in Gelsenkirchen, Germany, to the sewage and water pipelines in place all over the country. When designing this project we realized that it would be near impossible to take into account every scenario for a pipeline. It was decided to limit the scope of the paper to a simple gas or water pipeline that can be found in every neighborhood across the country. These pipelines are relatively straightforward and generally constructed using steel, pvc, or fiberglass. In our example we ran the program with a design limitation to install 8in. diameter steel pipe 6 ft. under ground for one mile. It was assumed that five percent of the right of way needed to be purchased and used the average price per acre in Texas. Silt soil composition was input and gave the project was given two months in the fall to complete with an hourly wage rate of \$7.50. A screen shot with these criteria and the resulting data can be seen below.

Cost Estimation for Running Pipeline

Pipeline Variables

Material: steel fiberglass

Length:
 feet miles

Depth: feet

Diameter: inches

Cost per linear foot:

Total cost of pipe:

Land Variables

Land acquisition: %

Avg. Price / Acre: \$

Soil composition:

Number of workers:

Estimated labor cost:

Labor Variables

Time schedule: months

Hourly wage: \$

Season of work:

Estimated land cost:

Estimated Final Cost: \$553,697.27

Compute Clear Form Exit

To check the results of this example two different sources were employed. The first is an eighty five page report by Nathan Parker of the University of California titled “Using Natural Gas Transmission Pipeline Costs to Estimate Hydrogen Pipeline Costs”. This report was done using steel pipe of various diameters in situations very similar to those in our example. The results of his report can be found below. The red highlights the diameter we are interested in to compare with our results.

Pipe Dia.	Materials	Labor	Misc.	Right of Way	Total
4" mean median %	\$60,017/mi \$30,570/mi 15%	\$268,585/mi \$232,980/mi 45%	\$101,668/mi \$63,414/mi 21%	\$56,222/mi \$38,301/mi 19%	\$486,492/mi \$364,523/mi
6"	\$57,863/mi \$46,086/mi 16%	\$239,916/mi \$182,299/mi 52%	\$115,264/mi \$65,610/mi 23%	\$54,364/mi \$36,519/mi 9%	\$467,407/mi \$333,601/mi
8"	\$93,436/mi \$55,278/mi 22%	\$208,658/mi \$146,203/mi 42%	\$139,034/mi \$85,832/mi 28%	\$36,947/mi \$26,011/mi 8%	\$478,076/mi \$306,925/mi
10"	\$102,258/mi \$70,143/mi 21%	\$246,771/mi \$196,864/mi 49%	\$110,033/mi \$78,635/mi 22%	\$43,427/mi \$46,461/mi 8%	\$503,489/mi \$456,532/mi

As shown in the data our estimated total cost only varies Nathan's average total cost by 15.82 percent. This is a very good percent error considering the many factors involved with a pipeline. The second set of data used to check the accuracy of the program was taken from R.W. Beck, Oil and Gas Services. The R.W. Beck Company has been around since 1942, and is a leader in the pipeline industry. They compiled the chart in Appendix A from over three thousand miles of new pipeline constructed in 2000 and 2001. The top chart in Appendix A was compiled by R.W. Beck, and the bottom shows the results produced by the program written for this project, using the same percentage of miscellaneous costs. As can be seen, the cost breakdown of our program shows reasonable results. Now that the accuracy of the program has been demonstrated, an explanation is needed as to why it is near impossible to create one simple program to estimate the cost of a pipeline. Programs that can generate accurate results for various scenarios cost several thousand dollars. Pipelines are dependent on so many different factors that it is difficult to have the required inputs unless it is your job to create the program. The predominant cost of building a pipeline falls into the category of

miscellaneous. This is proved in both of the charts used. Costs included in the miscellaneous category could include delays in the construction, special limitations put on the pipeline by land owners or the Environmental Protection Agency, and even the construction of new infrastructure to get needed supplies to remote areas. It could also include the expense of crossing any highways, which costs \$500,000 dollars per 300 feet of pipe laid. Right of way costs remain fairly constant, but they are dependent on where the pipeline is being built. Land surrounding an expanding city is going to cost much more than some barren desert land in West Texas. Cost of real estate also depends on the region of the country the pipe will be installed. Real estate in Florida and California is going to be more expensive than say North Dakota or Kansas. The location also plays a role in the special design requirements needed for the pipeline. For example, pipelines in Alaska must worry about the freezing tundra, areas along the gulf coast such as Louisiana and Florida must consider the swampy conditions and take into account the possibility of hurricanes, and any type of construction on the west coast must worry about earthquakes. Any pipeline constructed in these regions, or areas like them takes special planning and becomes a feat of engineering rather than just another pipeline. The cost of these pipelines must be estimated on a pipeline to pipeline basis. The makeup of the fluid being transported also plays a role in the cost of pipelines. Some fluids may be corrosive and require a special type of pipe, or be volatile and need to have precautions taken to insure safety. The cost of pipe does not have a steady price either. The pipe market is an ever changing one, and depends on several different industries and the economy. Steel pipe depends on the availability and cost of the raw materials needed to make steel, and then on the demand for the steel, whether it is from the pipe industry or some other steel

using industry such as construction. Fiberglass has a fairly steady supply of material, but the demand from other industries can easily raise or lower the price. The last category is labor. Everyone knows how much the cost of labor fluctuates with the season, economy, and region. For this reason we thought it would be best to leave the input of the cost of labor up to the program user. Over all it has been shown that this program is fairly competent, and we feel confident that if the conditions require a conventional pipeline and the user knows the current cost of labor and land, then reasonable cost estimate can be generated.

References

Big Bear Area Regional Wastewater Agency. Sept. 2005. 8 Dec. 2005
<http://www.bigbearwatersolutions.org/pdf_files/Chapter%207%20Cost%20Analysis.pdf>.

Institution of Transportation Studies. Dept. home page. U of California. 8 Dec. 2005 <<http://www.its.ucdavis.edu/publications/2004/UCD-ITS-RR-04-35.pdf>>.

"Pipeline transport." Wikipedia. 8 Nov. 2005. 8 Dec. 2005
<http://en.wikipedia.org/wiki/Pipeline_transport>.

Rafferty, Kevin D., P.E. "Piping." Geothermal Networks. 8 Dec. 2005
<<http://www.geothermie.de/egec-geothernet/prof/piping.htm>>.

R.W. Beck, Inc. R.W. Beck. 8 Dec. 2005 <http://www.rwbeck.com/market/energy/oil_gas/O-GBulletin-Pipeline_Cap_Cost.pdf>.

Appendix A

R.W. Beck:

The pipeline installed cost is broken into RoW & Damages, Material, Labor and Miscellaneous. The average cost breakdown of these four categories is shown in the following chart.

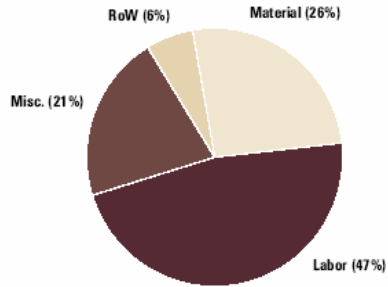


Chart 5 – Cost Breakdown, US

Pipeline Estimator:

