

BASIS OF ESTIMATE

Interior Gas Utility
Fairbanks Gas Distribution
Advancement Project
Task 3: LNG Storage Tank Cost Analysis

July 19, 2013



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INTRODUCTION

Total Installed Cost (TIC) estimates are developed for a number of reasons including: assessment of commercial opportunities, concept evaluation, and negotiations with third parties. Estimates are a key input to economic analysis to aid decision making at Capital stage gates and are developed throughout the project lifecycle. Estimates are prepared in Today's Money (present costs) and later, if required, escalated to Money-of-the-Day (future costs). Estimates encompass the complete scope of work for a project. The Association for the Advancement of Cost Engineering (AACE) classifies estimates by their accuracy and level of detail. For a project where design is 0-2% complete, for example a concept screening study or to evaluate feasibility, an expected accuracy range of +50%/-30% can be assumed; this is defined as a Class 5 estimate.

The project team members that contributed to the estimate development are shown in Table 1.

Table 1. Project Estimate Team

PROJECT ESTIMATE TEAM			
Name	Position/Role	Affiliation	Contact Info
Derek Christianson, P.E.	PM/Estimator QA	MBJ	273-1629
Vince Fernandez	Estimator	MBJ	273-1665

PROJECT SCOPE

The purpose of this estimate is to complete designated Task 3: LNG Storage Tank Cost Analysis, which has been assigned to Michael Baker, Jr. Inc. (Baker) by Northern Economics Incorporated (NEI). This task is a component of the request from the Interior Gas Utility (IGU) for updates to the previously submitted cost model provided by NEI for truck-based supply of LNG facilities to be sited at or near North Pole, Alaska. LNG supply volumes will be trucked from Deadhorse, North Slope to the North Pole LNG facility. Task 3 includes the following:

1. Determine the monthly variation of energy consumption for residential and commercial gas users in the Fairbanks area through a statistically significant sample.
2. Develop a model that incorporates the size, cost and number of tanks and idle truck trailers in summer.

This cost estimate reports on the total installed costs (TIC) for estimated supply and construction costs for an operationally suitable LNG tank, associated truck offloading facilities and the estimated capital cost for an LNG truck fleet.

METHODOLOGY

At the time of estimate detailed design was not available. Instead the design concept for this limited component of the larger scope LNG development project included:

- Transportation of LNG by specially-built truck tankers from a North Slope gas liquefaction plant via existing surface roads on a seasonal, year round basis for delivery to the Fairbanks, Alaska area
- Provision for LNG storage at a location within or near Fairbanks, Alaska
- Phased storage capacity construction including an initial LNG tank to match current demand, potentially followed by increased LNG storage if/when demand increase over time develops
- Associated ancillary facilities and infrastructure associated with the LNG storage tank(s)
- Facilities for offloading LNG truck tankers into the LNG storage tank(s)

The order of magnitude estimate approach was to take existing gas consumer demand data, including Heating Degree Day (HDD) and earlier conceptual parameters in order to establish a likely range of storage capacity and optimal number (and schedule) for the fleet of LNG truck tankers. Thus a selection of the physical facility and rolling stock requirements were established through analysis of anticipated monthly demand data.

The remaining step was to develop order of magnitude capital cost (CAPEX) estimates that include supply and construction of the LNG storage tank, which is the principal cost driver, as well as development of estimates for the truck unloading facilities and associated infrastructure for the LNG storage facility. A separate cost estimate was developed for the fleet of LNG truck tankers that would be required to adequately service the LNG storage tank(s) based upon anticipated year-round demand.

Estimates were prepared for (1) the base case which assumed initial installation of a small LNG tank of 7.5 million gallon capacity, and (2) an alternate case that would approximate future peak storage capacity requirement of 30 million gallons. For comparison purposes, costs for both Full Containment and Single Containment type LNG tanks were estimated.

COST BASIS

Through analysis of the available demand data, it was determined that the following were the base case facility and operational requirements:

LNG Storage Tank – Base Case Initial Requirement

A single LNG Storage Tank with a capacity of 7.5 million gallons

LNG Storage Tank – Alternate Peak Requirement Case

A single LNG Storage Tank capable of meeting peak storage requirement with a capacity of 30.0 million gallons

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Supply and install cost estimates for LNG Storage Tanks were developed from historical total installed costs data points that were provided by a world-scale designer, manufacturer and constructor of its own line of proprietary-engineered LNG storage tanks systems. Cost data was estimated from the data points and related factored facility costs as shown in Table 2.

Table 2. Cost Data Points

Description	Capacity (gallons)	Cost Data Point	Cost Factor
LNG Storage Tank – Full Containment ¹ w/ cryo pumps	7.5 million	\$60 million	1.025 on labor component
LNG Storage Tank – Full Containment w/ cryo pumps	44 million	\$135 million	
LNG Tank Foundation – ground conditioning ²		\$5 - \$15 million	
Associated Balance of Plant Systems ³			25% of full containment tank cost

1. See description below for full containment and single containment tanks
2. Ground conditioning may be required for: subsurface ice/permafrost; surcharging and related soil consolidation measures; and provisions to mitigate liquefaction during a seismic event
3. To include Service Piping, Electrical and Structural systems, civil site work and utility infrastructure

Full Containment LNG Storage Tank – The estimate for the LNG tank is based upon a “Full Containment” type as the most conservative cost approach. Full containment LNG tanks are generally configured as: Inner open topped main tank of 9% Ni Steel and a secondary fully enclosed concrete tank bottom, walls and cover. The concrete outer tank provides primary vapor containment and the secure secondary liquid containment. Full containment tanks are significantly more expensive vs. single containment LNG tanks but do not require added costs and land areas for external lined earthen dikes needed for regulatory requirement for secondary containment, nor do they usually have significant associated siting and permitting risks.

Single Containment LNG Storage Tank – the estimate did not consider the use of single containment LNG configurations, even though on the tank cost basis alone, there could be a 38% to 50% cost reduction vs. full containment. This cost savings is significantly offset by added infrastructure costs associated with meeting federal and state code requirements for 100% secondary containment. Single containment LNG tanks also have a main open top inner tank made of 9% Ni steel, and has an outer tank wall of carbon steel. The carbon steel wall does not afford secondary containment, but mostly act as primary vapor containment. For secondary containment a significant amount of land is required on site for the 100% diked containment that must be built and maintained to assure 100% capacity year round. In addition, permitting complications may be associated with siting a single containment LNG tank within a populated municipality. There would be mandatory modeling and testing of Vapor Dispersion and Thermal Dispersion and thermal affects studies for a spill event. Should client management select a single

containment LNG tank concept, these added costs and risks would need to be estimated and analyzed as offsets to the tank cost savings.

LNG Tank Cost – Base Case

Based upon the cost data point received for a 7.5 million gallon tank, the resulting order of magnitude costs, after adjustment for union labor, are as follows:

Estimated 7.5 million gallon LNG Tank = \$61,500,000 (Full Containment)

Estimated 7.5 million gallon LNG Tank = \$30,750,000 (Single Containment)

These costs include in-tank LNG pumps and boil-off gas compression system. As noted below, the cost of a berm-type secondary containment system must be added to the cost for a single containment tank.

LNG Tank Cost – Alternate Peak Case

Based upon the cost data point received for a 44 million gallon tank, the resulting order of magnitude cost, after adjustment for union labor, is as follows:

Estimated 30.0 million Gallon LNG Tank = \$109,966,000 (Full Containment)

Estimated 30.0 million Gallon LNG Tank = \$54,983,000 (Single Containment)

These costs include in-tank LNG pumps and boil-off gas compression system. As noted below, the cost of a berm-type secondary containment system must be added to the cost for a single containment tank.

Secondary Containment for Single Containment LNG Tanks

Separate estimates were developed for installation of the required secondary containment lined berm system that will be mandatory for the optional Single Containment LNG Tanks. The cost estimates were developed based upon estimates of secondary containment volumes, site grading, select gravel fill for berms, liner costs and civil construction of the berm system. The estimated secondary containment berm system estimates are as follows:

Berm System Cost = \$2,620,000 – 7.5 million gallon tank

Berm System Cost = \$6,060,000 – 30.0 million gallon tank

Associated Balance of Plant Systems

The firm that provided the LNG Tank cost data points normally estimates Balance of Plant (BOP) Systems at 25% of the full containment tank cost. This is understood to include LNG gasifier equipment, yard piping, plant electrical and instrumentation systems, power distribution center, flare system, plant control system, control building, odorant storage and injection skid, cooling/auxiliary skid, cooling fin fans, cooling circulation pumps, expansion tanks, plant firewater systems, etc.

Estimated BOP Systems = \$15,375,000 – 7.5 million gallon tank – Full Containment

Estimated BOP Systems = \$15,375,000 – 7.5 million gallon tank – Single Containment

Estimated BOP Systems = \$27,492,000 – 30.0 million gallon tank – Full Containment

Estimated BOP Systems = \$27,492,000 – 30.0 million gallon tank – Single Containment

Truck Unloading Rack/Facility

At the time of estimate detailed design was not available for the truck unloading facility, however a typical two station truck unloading layout was found in a recent study in the public domain. The equipment layout included an LNG Fueling Skid, Metering Skid, and fueling vapor recovery system. Based upon the estimator's previous experience in estimating these facilities, an order of magnitude estimate value was applied as follows:

Materials and freight	\$3,300,000
Construction and testing	<u>\$2,200,000</u>
Total	\$5,500,000

LNG Truck Tankers

A total of 117 new specially-built LNG truck tankers with a nominal capacity of 10,500 gallons of LNG are required to meet the anticipated demand.

Estimated Unit Cost per truck = \$400,000

Total Capital Cost for 117 trucks = \$46,800,000

This is for a specially-built truck with a strengthened chassis, trailer and breaking systems, and with the capability to operate on the Dalton Highway and fueled on natural gas derived from storage tank boil off.

DEMAND vs. REQUIREMENTS ANALYSIS

Annual Demand

Estimated annual and monthly demand was evaluated to determine the number of trucks required to meet peak demand. The annual demand for the Fairbanks North Star Borough was estimated at 10.8 billion cubic feet (bcf) of natural gas (Northern Economics Incorporated, June 2012) and converted to 130 million gallons of LNG at a conversion rate of 12 million gallons/bcf.

Monthly Demand

The annual demand was then converted to a monthly demand with the distribution based on the monthly degree days at the Fairbanks Airport (<http://www.wrcc.dri.edu/cgi-bin/cliMONthdd.pl?ak2968>). Next, storage tank sizing was determined based on an estimated minimum reserve volume capable of meeting demand for a given number of days during the peak demand month of January. Two tanks were sized to provide a range of reserve capacity covering potential scenarios. The first scenario provided 10 days of reserve volume and requires a 7.0 million gallon tank (a 7.5 million gallon tank was used as the estimating value). The second scenario provided 42 days of reserve volume and requires a 30 million gallon tank. Table 3 shows the monthly demand distribution values.

Table 3. Monthly Demand Distribution

Month	Days per Month	Average HDD	Demand (Gal LNG)	Gal LNG with 10 Days Reserve	Gal LNG with 42 Days Reserve
Jan	31	2,327	21,700,000	7,000,000	29,400,000
Feb	28	1,912	17,800,000	6,400,000	26,700,000
Mar	31	1,703	15,900,000	5,100,000	21,500,000
Apr	30	1,009	9,400,000	3,100,000	13,200,000
May	31	501	4,700,000	1,500,000	6,400,000
Jun	30	168	1,600,000	500,000	2,200,000
Jul	31	118	1,100,000	400,000	1,500,000
Aug	31	269	2,500,000	800,000	3,400,000
Sep	30	594	5,500,000	1,800,000	7,700,000
Oct	31	1,246	11,600,000	3,700,000	15,700,000
Nov	30	1,860	17,400,000	5,800,000	24,400,000
Dec	31	2,229	20,800,000	6,700,000	28,200,000
Totals	-	13,936	130,000,000	-	-

Truck Capacity

The estimated maximum number of trucks capable of providing the peak monthly reserve demand was then determined. This volume per day per truck was calculated based on truck capacity and the cycle time per truck. The estimated capacity per day per truck is estimated at 6,100 gallons. Table 4 shows the values used to estimate truck capacity.

Table 4. Truck Capacity and Haul Values

Item	Value
Truck Capacity:	10,500 Gal
Fbks->Prudhoe Roundtrip Dist:	1,000 miles
Avg Speed:	30 mph
Fbks->Prudhoe Roundtrip Time:	33 hours
Load/Unload Time:	8 hours
Cycle Time/Truck:	41 hours
Round Trips/Day/Truck:	0.59 each
Volume/Day/Truck:	6,100 Gal

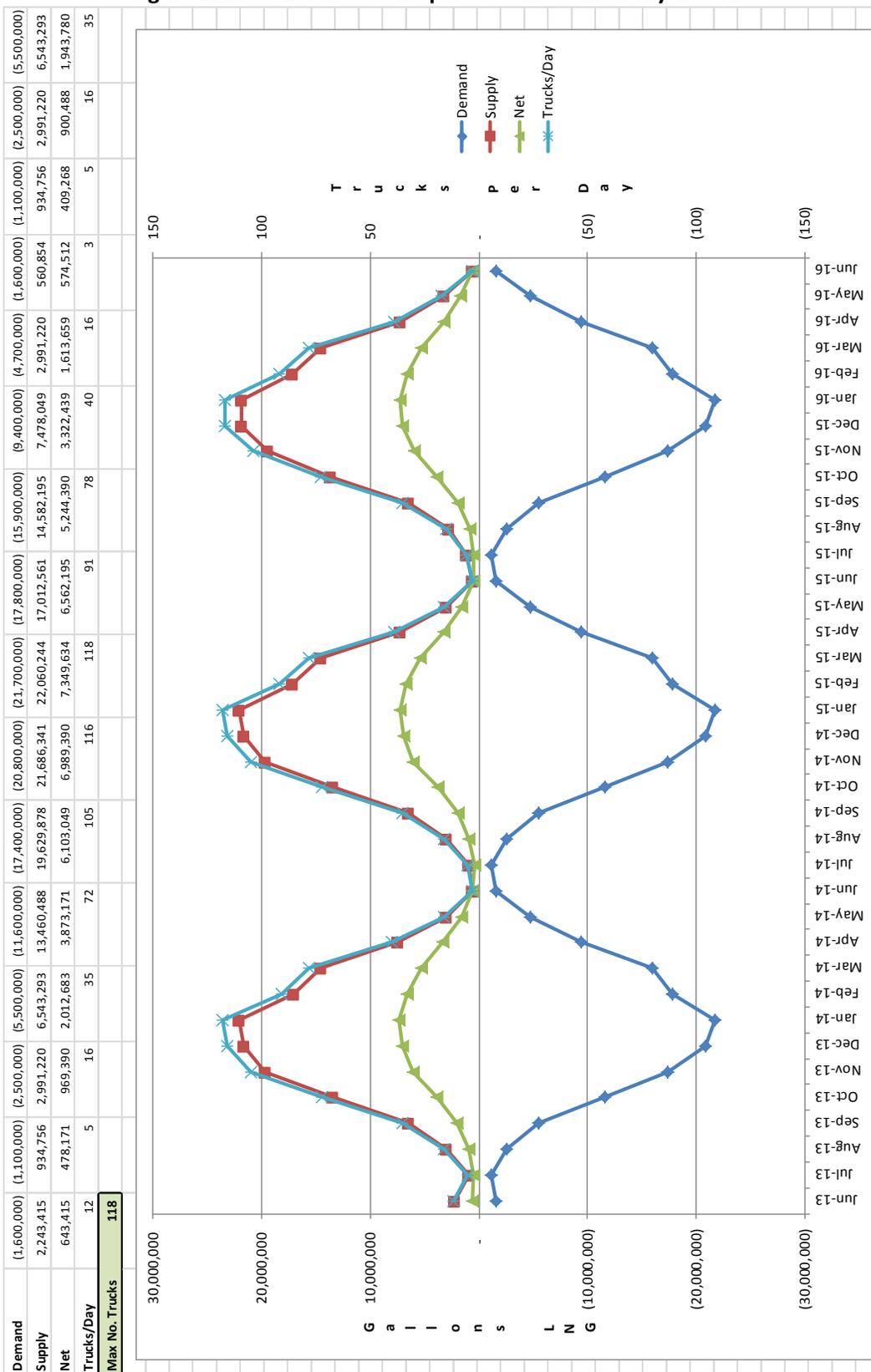
Trucks Required

Two approaches were taken to estimate the number of trucks required. Both approaches used a mass-balance calculation which summed the monthly demand and supply values to determine the net storage and resulting number of trucks required per month (it also accounts for the unused balance from the previous month). The difference in the two approaches is that the first calculated the number of trucks required to meet the minimum monthly reserve value, while the second calculated the number of trucks required to meet the greatest reserve demand value. Another way of comparing the approaches is that the first only fills the storage tank to meet the minimum monthly reserve whereas the second keeps the tank full. The first approach requires a greater number of trucks and was therefore not used for estimating costs. The second approach indicates 117 trucks are required and this value was used for estimating costs.

Figures 1 and 2 provide examples of the mass-balance graph and data for approach 1 and 2, respectively, for the 7.5 million gallon tank scenario.

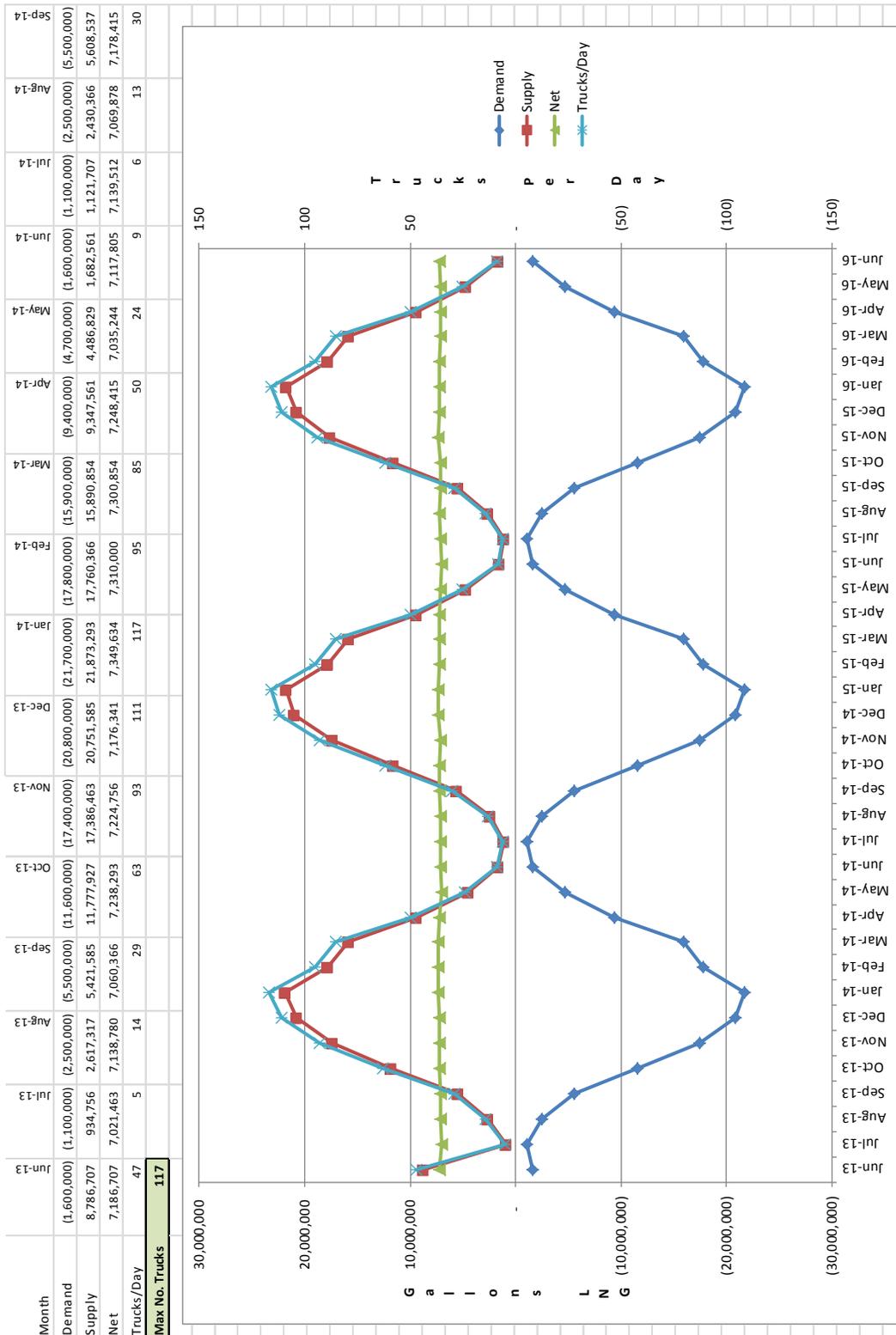
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Figure 1. Mass-Balance as Required to Meet Monthly Reserve



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Figure 2. Mass-Balance as Required to Maintain a Full Tank



DEVELOPMENT SCHEDULE

A preliminary high level schedule to design, permit, and construct the tank and ancillary features was developed. Engineering and Permitting efforts were estimated to have 12 month concurrent duration; Procurement was estimated to have a 3 month duration; and Construction was estimated to have a 30 month duration for the 7.5 million gallon tank and 42 months for the 30 million gallon tank. The schedule assumes the engineering and permitting activities will begin in early 2016. Construction is estimated to be complete by the end of 2019. Figure 3 shows the schedule for the 7.5 million gallon tank and Figure 4 shows the schedule for the 30 million gallon tank.

Figure 3. 7.5 MGal Tank Preliminary Schedule

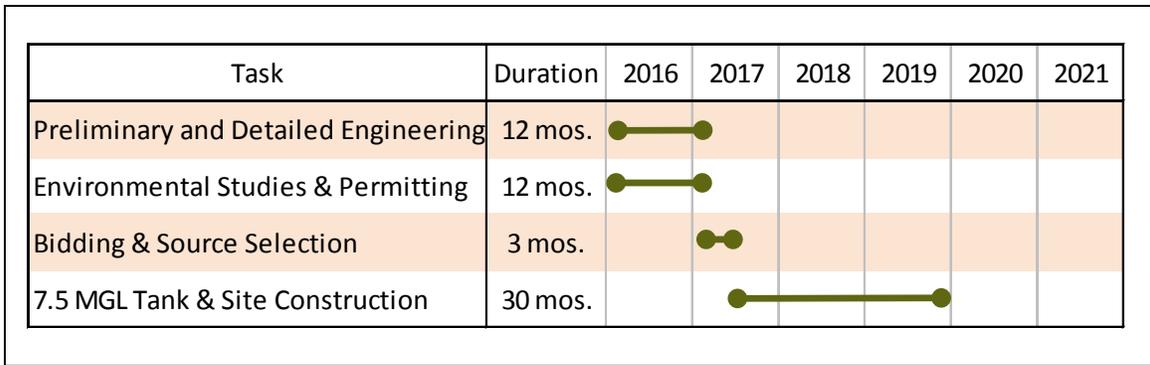
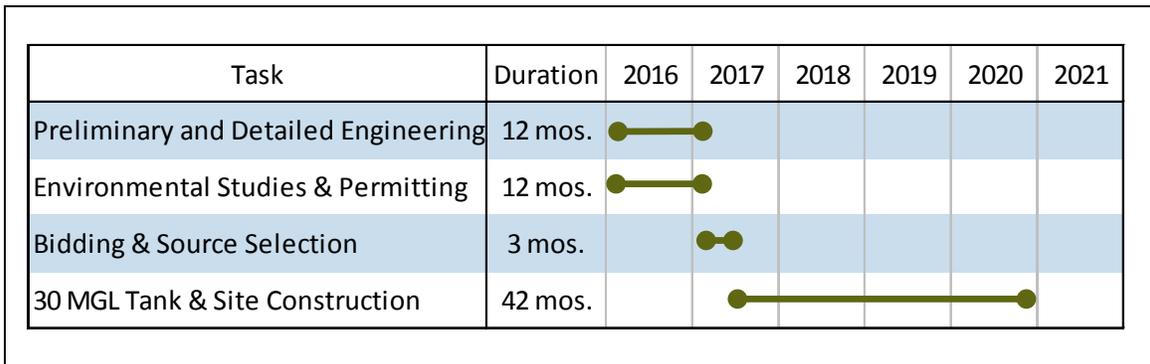


Figure 4. 30 MGal Tank Preliminary Schedule



COST SUMMARY**Base Case: Initial 7.5 million gallon LNG Tank with Truck Unloading Facility and LNG Truck Tanker Capital Cost – Full Containment**

Description	Quantity	Cost Estimate
LNG Storage Tank – Full Containment w/ cryo pumps	1	\$61,500,000
LNG Tank Foundation – ground conditioning	lot	\$5,000,000
Associated Balance of Plant Systems	lot	\$15,375,000
LNG Truck Tankers	117	\$46,800,000
Truck Unloading Rack/Facility	lot	\$5,500,000
Subtotal		\$134,175,000
Contingency @ 20%		\$26,835,000
Total Cost Range (+50% to -30%)		\$241,500,000 to \$112,700,000

Base Case: Initial 7.5 million gallon LNG Tank with Truck Unloading Facility and LNG Truck Tanker Capital Cost – Single Containment

Description	Quantity	Cost Estimate
LNG Storage Tank – Full Containment w/ cryo pumps	1	\$30,750,000
LNG Tank Foundation – ground conditioning	lot	\$5,000,000
Associated Balance of Plant Systems	lot	\$15,375,000
LNG Truck Tankers	117	\$46,800,000
Truck Unloading Rack/Facility	lot	\$5,500,000
Berm System	lot	\$2,620,000
Subtotal		\$106,045,000
Contingency @ 20%		\$21,209,000
Total Cost Range (+50% to -30%)		\$190,900,000 to \$89,100,000

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Alternate Case: 30.0 million gallon peak LNG Tank with Truck Unloading Facility and LNG Truck Tanker Capital Cost – Full Containment

Description	Quantity	Cost Estimate
LNG Storage Tank – Full Containment w/ cryo pumps	1	\$109,966,000
LNG Tank Foundation – ground conditioning	lot	\$5,000,000
Associated Balance of Plant Systems	lot	\$27,492,000
LNG Truck Tankers	117	\$46,800,000
Truck Unloading Rack/Facility	lot	\$5,500,000
Subtotal		\$194,758,000
Contingency @ 20%		\$38,952,000
Total Cost Range (+50% to -30%)		\$350,600,000 to \$163,600,000

Alternate Case: Initial 30.0 million gallon peak LNG Tank with Truck Unloading Facility and LNG Truck Tanker Capital Cost – Single Containment

Description	Quantity	Cost Estimate
LNG Storage Tank – Full Containment w/ cryo pumps	1	\$54,983,000
LNG Tank Foundation – ground conditioning	lot	\$5,000,000
Associated Balance of Plant Systems	lot	\$27,492,000
LNG Truck Tankers	117	\$46,800,000
Truck Unloading Rack/Facility	lot	\$5,500,000
Berm System	lot	\$6,060,000
Subtotal		\$145,835,000
Contingency @ 20%		\$29,166,900
Total Cost Range (+50% to -30%)		\$262,500,000 to \$122,500,000

ASSUMPTIONS & DESCRIPTION OF WORK

The following are the assumptions that were applied to the order of magnitude:

1. A long established and successful designer/manufacturer/constructor firm was consulted for assistance with the LNG cost data points used in this estimate. This firm is a large corporate entity that is known for its world-scale energy engineered equipment and infrastructure products. Based upon considerable discussion regarding current parameters, this firm provided the cost data points noted.
2. The data points for LNG tank costs are based upon Lower 48 construction cost using open shop (non-union) labor. For the estimates an uplift factor of 1.025 has been applied for the final cost estimate in order to account for the labor component of the total cost that is associated with interior Alaska construction productivity and union labor.
3. The firm further indicated that the 7.5 million gallon LNG tank typically has a 24 month field erection duration on Lower 48 sites. A 44 million gallon tank typically has a 36 month duration. Therefore for the Fairbanks/North Pole site, and the anticipated mandatory winter shutdowns, it is anticipated that tank construction could be extended by approximately 6 – 12 months, including the initial engineering.
4. Cost of land for siting the LNG Tank and related plant systems is not included in this estimate.
5. No significant additional facilities or infrastructure will be required from eventually secured construction and operating permits.
6. Adequate labor supply and life support resources will be available during the development and construction project phases.
7. All onsite craft labor will be union labor dispatched by local Anchorage or Fairbanks union halls. Specialty craft such as Boilermakers and Millwrights may be dispatched from lower 48 jurisdictions.
8. Adequate funding available for this project.
9. All costs are based on 2013 dollars.
10. All materials and equipment will be on the construction site as scheduled.
11. Estimated costs are based on factored or interpolated costs from prior construction activities.
12. Contractor markup and profit is included in factored price per linear foot for installation.
13. Weather delay costs are not included.
14. Engineering, permitting, procurement, and freight costs are included in the order of magnitude estimated costs.
15. Owner's Program/Project Management costs are not included.

CONTINGENCY

The contingency calculation is used to cover the uncertainty and variability associated with a cost estimate, as well as unforeseeable elements of cost within the defined project scope. The

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contingency costs cover field uncertainties, inadequacies in complete project scope definition, estimating methods, and estimating data. Contingency specifically excludes changes in project scope, and unforeseen major events such as earthquakes, prolonged labor strikes, weather delays, etc. The amount of contingency is based on the AACE estimate class 5.

The contingency level used for this estimate is +20%.

QUALITY ASSURANCE

The Baker estimate Quality Assurance lead, in consultation with the Baker Project Estimating Team members, reviewed the estimate to verify that it employs the appropriate, methodologies, assumptions and exclusions, appropriate rates and factors and addresses the entire project scope and nothing beyond the approved scope.

If the estimate is reasonable and adequately addresses the project scope and requirements, the Baker QA lead communicates acceptance of the estimate to the Baker Cost Estimating Function Lead/Project Manager. If the estimate is insufficient or the exclusions are not acceptable, the Baker Chief Engineer communicates the need to correct or improve the estimates to the Baker Cost Estimating Function Lead/Project Manager.

All reviews of the estimate, as well as all the review participants are documented below in the "Project Estimate Review Log".

PROJECT ESTIMATE REVIEW LOG			
Estimate Reviewed by	Position/Role	Affiliation	Date
Derek Christianson	QA	MBJ	7/15/13

REFERENCES

Many documents were collected, reviewed and referenced during the development of the estimate. Since these documents ultimately form the basis for the resulting estimated cost, the basis of estimate should contain a record of each of these documents. All project plans, technical documents, and drawings should be itemized and accurately described in the appropriate section of the basis of estimate.

The "Project References and Attachments Log" below includes all major documents associated with the estimate including, but not limited to: any design drawings or technical documents (e.g. P&IDs, Isometrics, etc.), project review meeting minutes, copies of important correspondences, etc.

PROJECT REFERENCES & ATTACHMENTS LOG	
Document Title or Description	Date Issued
Northern Economics Memorandum – Re: Projected Natural Gas Demand, per Residential Unit	5/3/2013

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Northern Economics Memorandum – Re: Estimated Natural Gas Demand for NS LNG Project	6/21/2013
Caribou North Slope, LLC Liquefied Natural Gas Project, Caribou North Pole, LLC, Vaporization Facility Project, Project Description	10/2013
Northern Economics Report – Fairbanks North Star Borough, Gas Distribution System Analysis	6/29/2012
AIDEA Report: Interior Energy Plan: North Slope / Fairbanks LNG Project, Engineering Brief and Consultant Team Recommendations	4/23/2013