Fairbanks North Star Borough

Gas Distribution System Analysis

June 29, 2012

Prepared by

Northern Economics

880 H Street, Suite 210
Anchorage, Alaska 99501
Phone: (907) 274-5600
Fax: (907) 274-5601
Email: mail@norecon.com

119 N Commercial Street, Suite 190
Bellingham, WA 98225
Phone: (360) 715-1808
Fax: (360) 715-3588

In association with

Michael Baker, Jr. Inc.

SLR International

Alaska Energy Board

PROFESSIONAL CONSULTING SERVICES IN APPLIED ECONOMIC ANALYSIS

Principals:
Patrick Burden, M.S. – President
Marcus L. Hartley, M.S. – Vice President
Jonathan King, M.S.

Consultants:
Joel Ainsworth, B.A.
Alexus Bond, M.A.
Leah Cuyno, Ph.D.
Michael Fisher, MBA
Cal Kerr, MBA
Alejandra Palma, M.A.
Bill Schenken, MBA
Don Schug, Ph.D.
Katharine Wellman, Ph.D.

Administrative Staff:
Diane Steele – Office Manager
Terri McCoy, B.A.
Michelle Humphrey, B.S.

Northern Economics

880 H Street, Suite 210
Anchorage, Alaska 99501
Phone: (907) 274-5600
Fax: (907) 274-5601
Email: mail@norecon.com

119 N Commercial Street, Suite 190
Bellingham, WA 98225
Phone: (360) 715-1808
Fax: (360) 715-3588

Preparers

Team Member	Project Role	Firm
Patrick Burden	Project Manager	Northern Economics, Inc.
Cal Kerr	Assistant Project Manager	Northern Economics, Inc.
Leah Cuyno	Economist	Northern Economics, Inc.
Mike Fisher	Analyst	Northern Economics, Inc.
Alejandra Palma-Riedel	Economist	Northern Economics, Inc.
Joel Ainsworth	Analyst	Northern Economics, Inc.
Derek Christianson	Baker Project Manager	Michael Baker, Jr. Inc.
Charles Barnwell	GIS Lead	Michael Baker, Jr. Inc.
Vin Robinson	Cost Estimator	ENSTAR Natural Gas
Carolyn Dunmire	Strategic Planning	Alaska Energy Board
Jeff Staser	Funding Strategies	Alaska Energy Board
Tony Izzo	Gas Utility Operations	Alaska Energy Board
Al Trbovich	Task Lead, Air Quality	SLR International
Courtney Kimball	Task Support, Air Quality	SLR International
Terri McCoy	Technical Editor	Northern Economics Inc.

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Abbreviations

AAC	Alaska Administrative Code
AFUE	Annual Fuel Utilization Efficiency
AIDEA	Alaska Industrial Development and Export Authority
ANS	Alaska North Slope
BCA	Benefit-cost analysis
Bcf	Billion cubic feet
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
Btu	British thermal units
CNG	Compressed Natural Gas
CO	Carbon monoxide
COS	Cost-of-Service
DEC	Alaska Department of Environmental Conservation
DOT	U.S. Department of Transportation
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FMA	Free Main Allowance
FNG	Fairbanks Natural Gas, LLC
FNSB	Fairbanks North Star Borough
FY	Fiscal Years
GIS	Geographic information system
GVEA	Golden Valley Electric Association
ISER	Institute of Social and Economic Research, University of Alaska
kWh	Kilowatt-Hour
LID	Local Improvement District
LNG	Liquefied Natural Gas
Mcf	Thousand cubic feet
MMBtu	Million British thermal units
MMcfd	Million cubic feet per day
MW	Megawatt
NEPA	National Environmental Protection Act
NO_X	Oxides of nitrogen

PA	Propane-air
PESR	Preliminary Executive Summary Report
PM	Particulate matter (2.5 and 10.0 microns or micrometers)
PSI	Pounds per square inch
RCA	Regulatory Commission of Alaska
RFP	Request for Proposal
RMA	Risk Management Association
ROW	Right-of-way
SIP	State Implementation Plan
SO_2	Sulfur dioxide
Tpy	tons per year
SWOT	Strengths, Weaknesses, Opportunities, Threats
TIC	Total Installed Cost
TPY	Tons of pollutant emitted per year (also tpy)
VOC	Volatile organic compounds

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- **Gas Distribution System Management Team:**
  - Frank Abegg
  - Steve Haagenson
  - Dr. Paul Metz
  - Bob Shefchick
- **Gas Distribution System Advisory Committee:**
  - Luke Hopkins, Mayor, FNSB
  - Jerry Cleworth, Mayor, Fairbanks
  - Doug Isaacson, Mayor, North Pole
  - Bill Butler, for North Pole Mayor
  - Brian Rogers, Chancellor, University of Alaska Fairbanks
  - Lisa Herbert, Greater Fairbanks Chamber of Commerce
  - Brian Newton, GVEA
  - Gene Therriault, GVEA
  - Jeff Cook, Flint Hills Resources
  - Jerry Isaac, Tanana Chiefs Conference
  - Edward Cartner
  - Lorna Shaw, Greater Fairbanks Chamber of Commerce
  - Keith Walters , Usibelli Coal Mines
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  - Dan Britton
  - Dan Fauske, AHFC/AGDC
  - LtCol Mike Sheredy, Eielson AFB
  - Col Thomas Daak, Eielson AFB
  - Col Ron Johnson , Fort Wainwright
  - Jim Hemsath , AIDEA
  - Mike Meeks , Ft WW Public Works
  - Ross Adkins, North Star Air Quality Task Force
  - Leslye Langla, AGDC
  - Dave Howden, AGDC
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Fuel Cost Comparison Aid, June 2012

Several readers and reviewers of initial drafts of this report noted difficulty in converting costs between the three main fuels used in Fairbanks: fuel oil, propane and natural gas. In an effort to address this issue, the project team developed the following conversion aid, based on June 2012 prices in Fairbanks.

The table below shows fuel oil costs from $1.00 to $7.00 per gallon, along with corresponding propane costs (on a per gallon basis) and natural gas costs on a per MCF (1,000 cubic feet) basis. For reference, Anchorage's current cost of residential natural gas (rounded to $11.00 per MCF) is highlighted in blue and Fairbanks' current cost of fuel oil (rounded to $4.00 a gallon) is highlighted in red.

Simplified Fuel Cost Comparison: Fuel Oil, Propane, Natural Gas

Location, Tariff, System	Fuel Oil, $/gallon	Propane, $/gallon	Natural Gas, $/MCF
	1.00	1.12	7.96
Anchorage June 2012	**1.38**	**1.54**	**11.00**
	2.00	2.24	15.92
	3.00	3.35	23.88
Fairbanks, June 2012	**4.00**	**4.47**	**31.84**
	5.00	5.59	39.80
	6.00	6.71	47.76
	7.00	7.83	55.72

Source: Northern Economics.

More specifics are contained in Table 15 of the report, along with a June 2012 ranking of fuels based on cost.

Executive Summary

Current high energy prices in the Fairbanks North Star Borough (FNSB) are adversely affecting families and businesses in the borough. The doubling in the price of crude oil over the past five years, and the subsequent increase in the price of refined petroleum products has more than doubled the cost of space heating, electric generation, and transportation in Interior Alaska.

High energy prices coupled with increased scrutiny regarding air quality, specifically $PM_{2.5}$ (particulate matter that is 2.5 microns and smaller) have the potential to stifle economic development in the borough.

In response to these issues, the FNSB issued a Request for Proposals (RFP) for development of an optimized plan for a rapid build-out of the borough's proposed energy distribution system. The analysis was also directed to assess the potential for improved air quality by switching from primarily fuel oil and wood to natural gas or propane.

Project Goals

As stated by the FNSB, there are two overarching goals for the study:

1. To define a supply-neutral optimized plan for the rapid build-out of the FNSB's energy distribution infrastructure, one that delivers propane or natural gas as affordably as possible, to the largest number of borough residents, business and residential properties; and
2. To assess the impact of the proposed infrastructure build-out on air quality in the Fairbanks North Star Borough nonattainment area.

Major Findings

Construction and operation of a piped natural gas distribution system in the high-density and medium-density areas of the FNSB (See Figure ES-1), and a propane distribution system in the low-density areas of the borough, has the potential to reduce fuel costs for space heating of residential and commercial structures from approximately $524 million in 2021, the first full year of operations, to about $210 million, a savings of roughly $315 million annually (See Table ES-5.), a savings of 60 percent compared to the status quo using fuel oil and wood. These estimates will change with different assumptions or if capital costs or commodity costs change, but the magnitude of the savings is so large that it is evident that substantial savings will accrue under almost any future scenario that employs natural gas and propane.

Similarly, converting to natural gas for space heating will reduce the overall emissions of $PM_{2.5}$ in the Fairbanks area by a significant amount (See Figure ES-3). The conversion to natural gas will also reduce NO_X and SO_2 emissions, which are precursors to the formation of secondary $PM_{2.5}$ in the atmosphere. Combined, these emission reductions will help bring the Fairbanks area into attainment with the ambient $PM_{2.5}$ air quality standard. $PM_{2.5}$ emissions are estimated to decrease from approximately 2,200 tons per year to less than 200 tons per year.

Background

Northern Economics, based in Anchorage, created a project team with economists, business analysts, pipeline distribution system engineers and air quality specialists to suggest an organization and structure for development of the conceptual system.

The project began on December 29, 2011 and the team prepared a Preliminary Executive Summary Report in late January 2012. That preliminary report became the basis for this final report, which contains updates, greater detail, and results of more intensive analysis.

Project analysis and results for the executive summary are organized into the following sections:

- Market Demand
- Conceptual Design
- Business Models
- SWOT Analysis
- Cost of Service, Financial Analysis
- Consumer Savings
- Benefit-Cost Analysis
- Air Quality
- Decision Points

The key points for each section are summarized in the remainder of this Executive Summary.

Market Demand

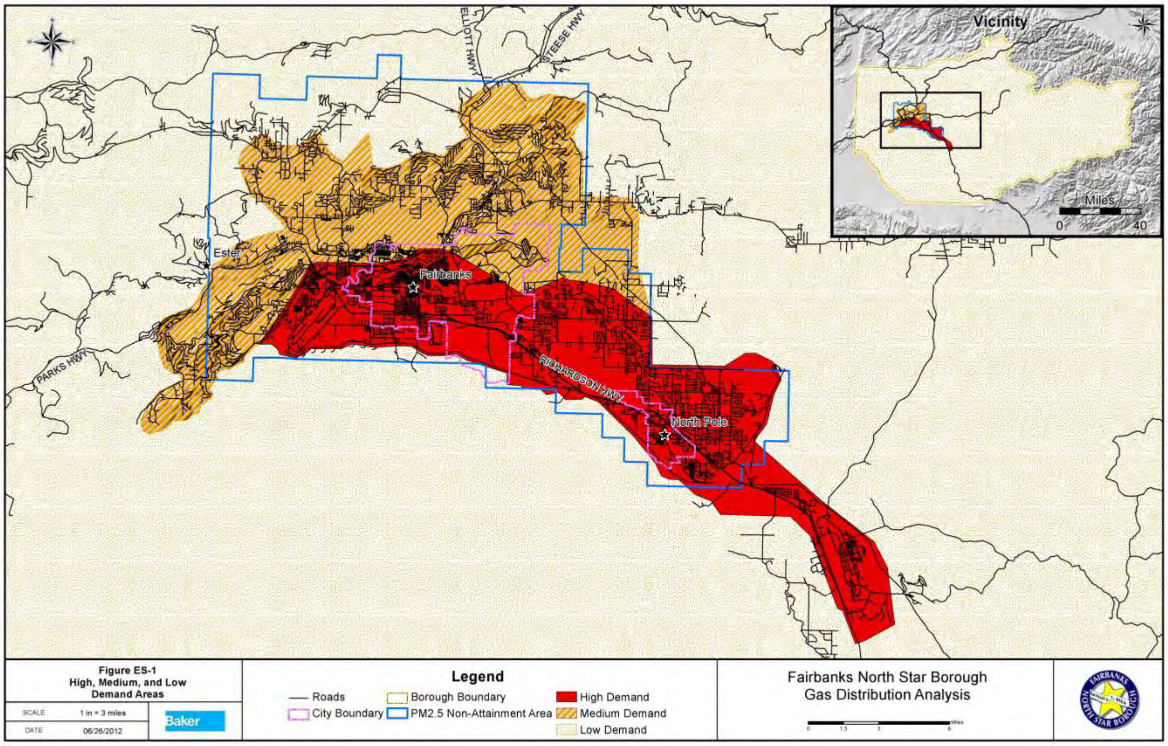
Total estimated market potential for natural gas or propane in the Fairbanks North Star Borough is equivalent to 20.5 billion cubic feet (Bcf) per year or an average of 56 million cubic feet per day. This estimate assumes that all existing residential and commercial structures plus specific industrial sector facilities will convert to natural gas or propane for heating, power generation, and processing requirements. However, not all of the households and businesses in the borough will be served by the natural gas distribution system or switch to natural gas or propane due to the fact that some structures are presently served by other utility systems, some businesses have plans to source their energy needs internally, and some structures in the low-demand area do not have significant heating loads because they are only used seasonally. As a result of these adjustments, the estimated market demand is equivalent to 11.5 Bcf per year rather than 20.5.

The estimated potential natural gas demand for the industrial sector assumes that an existing 60 megawatt combustion unit owned by Golden Valley Electric Association that currently burns naphtha would convert to natural gas and that the Flint Hills and Petro Star refineries in the North Pole would also convert to natural gas for their refining operations.

Market penetration for natural gas in the region has been limited due to supply constraints. In 2011, Fairbanks Natural Gas (FNG) sold 841,288 thousand cubic feet of gas to all its customers. This volume represents only four percent of the total estimated market potential for natural gas in the region. Access to natural gas and expansion of the existing distribution infrastructure are necessary in order for the market for natural gas to grow.

The RFP specified three zones for analysis: a high-density zone, a medium-density zone, and a low-density zone, all radiating from the heart of downtown Fairbanks. An analysis using geographic information system (GIS) software was undertaken to identify these zones. See Figure ES-1.

Figure ES-1. Fairbanks North Star Borough $PM_{2.5}$ Zone of Non-attainment and Three Demand Zones.



Source: Baker Engineers, FNSB, DEC, EPA.
Note: A larger format map is available in Appendix A of this report.

Table ES-1 summarizes the total market potential for natural gas or propane for the residential, commercial, and industrial sectors within each of the demand areas.

Table ES-1. Potential Natural Gas or Propane Requirements in the High, Medium, and Low-Demand Areas by Category

Category	High Demand	Medium Demand	Low Demand	Total
	Bcf/Year			
Residential	**3.27**	**2.28**	**0.84**	**6.38**
Commercial	**5.58**	**0.43**	**0.16**	**6.18**
Taxable Structures	5.06	0.34	0.16	5.56
Non-Private Structures	0.52	0.09	0.01	0.61
Industrial	**7.90**	**0.00**	**0.00**	**7.90**
Power Generation	3.1	0	0	3.1
Refinery Processing	4.8	0	0	4.8
Total	**16.75**	**2.71**	**1.00**	**20.46**

Source: Michael Baker Jr. and Northern Economics estimates.

Notes: The “Non-private structures” category generally refers to schools, government buildings, and other structures owned by non-private entities. Natural gas requirements for residential and commercial structures were estimated using square footage data available from the FNSB Assessor and secondary sources as well as information on average base and heating loads provided by ENSTAR for particular size and types of structures, adjusted for Fairbanks heating degree days. Natural gas requirements for the industrial sector were estimated using information provided by Golden Valley Electric Association, Flint Hills Refinery, and secondary sources. Totals and subtotals may not add due to rounding.

The natural gas distribution system will not deliver gas to all households and businesses in the FNSB because some are already served by FNG or by Aurora Energy, which delivers steam and hot water within its service area, and the low-demand area does not have housing densities sufficient to economically justify a piped distribution system. In addition, Golden Valley Electric Association (GVEA) and the Flint Hills North Pole refinery have proposed a liquefaction plant on the North Slope and trucking liquefied natural gas to their plants so this industrial demand would not be served by the piped distribution system. Furthermore, there are a number of residential structures in the low demand area that were vacant at the time of the 2010 census due to being recreational or seasonally occupied cabins that are not heated in the winter and have a minimal heating load in other times of the year. Taking these factors into account results in an adjusted market demand of 11.5 Bcf per year (Table ES-2). The potential market that will be served by the piped distribution system is also shown in Table ES-2. The remaining volumes of the adjusted market demand not served by the piped distribution system are anticipated to be served by propane or propane-air systems. Note that prices of natural gas and propane compared to competing fuels will affect the amount of gas or propane that is ultimately sold. See Section 2.6 for a discussion of natural gas and propane sales.

Table ES-2. Potential and Adjusted Market Demand

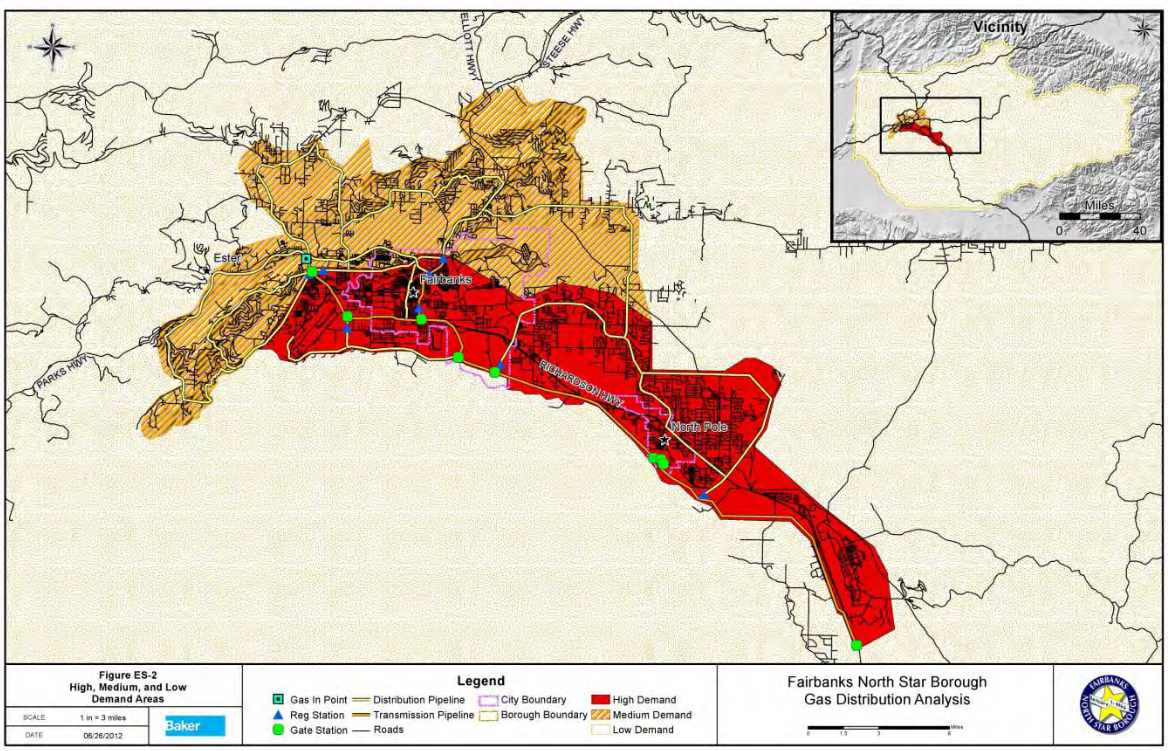
Category	Total Estimated Market Potential	Adjusted Market Demand	Potential Market Served by Piped Distribution System
		Bcf/Year	
Residential Sector	6.4	6.1	5.6
Commercial Sector	6.2	5.1	4.9
Industrial Sector	7.9	0.3	0.3
Total	**20.5**	**11.5**	**10.8**

Source: Michael Baker Jr. and Northern Economics estimates.

Conceptual Design

Project engineers designed a conceptual piped distribution system layout, as shown in Figure ES-2, for the high and medium density zones. The high-density area system would be completed in 2015 with conversions to natural gas occurring over a five-year period ending in 2019. The medium-density zone pipeline system would be completed in 2016, with the conversions occurring through 2020. The low-density zone would be served with propane using piped propane-air system or a similar distribution system as exists today with trucks delivering propane to individual residences and businesses, with conversions occurring over the 2015 to 2019 period. The conceptual design meets the objectives of providing lower-cost energy to as many residents and businesses in the FNSB as possible with an optimized schedule.

Figure ES-2. Conceptual Distribution System Layout



Source: Michael Baker, Jr. Inc.

Note: A larger format of this map is available in Appendix A of this report.

Design engineers developed a detailed cost estimate, contained in Appendix B of this report, based on 7.4 million lineal feet of piping (transmission, distribution, service), approximately 1,400 miles. A cost estimate, based on Level 4 classification by the Association for the Advancement of Cost Engineering ranged from $282.8 million (-30 percent) to $606.0 million (+50 percent), with a base estimate of $404.0 million. As project planning and design continues, the cost estimate will be refined with the range becoming narrower.

Business Models

Choosing a specific type of organization to implement the gas distribution system raises different issues regarding management, governance and ratepayer control, the efficiency of raising capital, and regulatory requirements, and a number of other topics. Regardless of the organizational preference, to be considered effective, any business structure needs to minimize the cost of providing service while incentivizing residences and businesses to convert to natural gas in a timely manner.

For the purposes of this report, the likely business structures which could be implemented for the FNSB Natural Gas Distribution System include:

1. Private Company;
2. Non-Profit or Public Entity such as Cooperative or Municipal Utility or Local Improvement District; or
3. Public/State Partnership.

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis (below) provides specific abilities of each business structure to achieve the goal of expanding and maintaining a gas distribution system, but the results of a quantitative analysis discovered the differences in cost of capital, taxes, and profits accounts for about nine percent of the overall cost to consumers.

On a cost basis alone, the difference between business models is not likely to be the determining factor driving customers to switch over to natural gas.

SWOT Analysis

The SWOT analysis is based on the ability of the organization to meet the primary goals of achieving the lowest cost energy to the most residences and businesses in the Fairbanks area as soon as possible. The specific aspects considered in the SWOT analysis are based on preliminary system design and costs estimates.

A full list of each organizational structure's Strengths, Weaknesses, Opportunities, and Threats is included in Table 11 through Table 14 later in the report. A summary of that analysis is presented in Table ES-3.

Table ES-3 Summary of SWOT Analysis

Organizational Structure	Strengths	Weaknesses	Opportunities	Threats
Private Company	Ability to raise capital for initial distribution system	Highest cost of service option	Potential sales tax income	Stability of future corporation
Non-Profit	Potential for lowest cost of service	May not have bonding capacity to construct the system	May qualify for funding partnership with the State	Potentially least flexible of the business structures
Local Improvement District	Access to borough's special assessment bonding capability	Borough assumes the risk of repayment for construction	Borough can benefit from taxes on gas utility	A decline in property values may create difficulty in repaying bonds
State Partnership	Lowest cost of service	Complicated ownership structure	Can leverage state investment and technical support	Uncertain regulatory requirements

Source: Alaska Energy Board

The SWOT and cost of service analysis indicate that a state partnership organization, especially with the support of grants or loan guarantee arrangements, could substantially improve project returns and end-user affordability. This business organization is the most likely to result in end-user costs near the $15 MMBtu target to promote solid fuel switching. With the monetary backing and financial support of the state, the state partnership is also most likely to achieve the trifold community goals of the lowest costs, for the broadest service area, within five years or less.

Cost of Service, Financial Analysis

The cost of service (COS) is the cost of the natural gas delivered to the end consumer. It includes the cost of the purchased gas, transportation to the city gate at Fairbanks, operations and maintenance costs, general and administration costs, depreciation, debt service, and other factors. Guidelines from the Federal Energy Regulatory Commission were used to calculate the COS reported here. However, within Alaska, the Regulatory Commission of Alaska (RCA) issues certificates and requirements for public utilities; including two natural gas utilities. The RCA does not issue guidelines for calculating the COS for natural gas utilities (3AAC52.010), though it does publish regulations for electric power COS calculations (3AAC48.500).

Table ES-4 summarizes the estimated cost of service for the piped distribution area, consisting of the high and medium-density areas, using proposed operations as a private company and a public organization. Note that the costs shown in the table are based on a specific set of assumptions described in the body of the report. For example, conversion costs from fuel oil to natural gas are not included in COS calculations.

Changes in assumptions, capital costs, or commodity costs will change these results. However, in general it is anticipated that a private organization will have a higher cost of service due to a private company having a higher cost of capital, higher taxes, and other factors.

Table ES-4. Estimated Cost of Service, Natural Gas, by Organization, Piped Distribution Area, 2015 to 2020, in $/MMBtu

Piped Distribution Area Gas Price (Medium, High)	2015	2016	2017	2018	2019	2020
Private Company						
Total cost per MMBtu	$20.56	$18.41	$17.77	$17.77	$17.97	$18.26
Total selling value with 20% margin over cost	24.67	22.09	21.32	21.32	21.56	21.91
Public Organization or Cooperative						
Total cost per MMBtu	$20.12	$16.67	$16.06	$16.07	$16.29	$16.59
Total selling value with10% margin over cost	22.13	18.34	17.67	17.68	17.92	18.25
Difference in Total Cost of Service	2.54	3.76	3.66	3.65	3.65	3.66

Source: Northern Economics, Inc.

Consumer Savings

The natural gas and propane alternative results in substantial savings for residents and businesses in the borough compared to the status quo. Table ES-5 shows the estimated annual fuel costs for the status quo and the natural gas and propane alternatives for the 2015 through 2022 time period, and the resultant cost savings.

Table ES-5. Fuel Costs and Savings

Alternative/ Sector	2015	2016	2017	2018	2019	2020	2021	2022	Total 2015-2021	Total 2015-2022
	(Millions of Nominal $)									
Status Quo										
Residential	219.9	223.3	234.9	245.2	255.6	266.3	277.5	289.7	1,722.7	2,012.4
Commercial	187.3	189.8	200.0	209.0	218.0	227.3	237.1	247.7	1,468.5	1,716.2
Industrial	8.0	8.0	8.3	8.6	8.9	9.2	9.5	9.8	60.6	70.4
Total	415.1	421.2	443.2	462.8	482.6	502.9	524.1	547.3	3,251.8	3,799.1
Natural Gas/Propane										
Residential	213.5	193.5	168.4	139.4	119.5	116.5	120.2	124.2	1,071.1	1,195.3
Commercial	178.4	141.9	102.1	80.4	79.4	81.7	84.1	86.8	748.1	834.9
Industrial	7.0	5.0	4.8	4.8	4.9	5.0	5.1	5.2	36.6	41.8
Total	399.0	340.4	275.3	224.7	203.8	203.2	209.5	216.2	1,855.8	2,072.0
Savings										
Residential	6.3	29.8	66.5	105.8	136.1	149.8	157.3	165.5	651.6	817.1
Commercial	8.8	47.9	97.9	128.5	138.7	145.7	152.9	160.9	720.4	881.3
Industrial	1.0	3.0	3.5	3.8	4.0	4.2	4.4	4.7	24.0	28.7
Total	16.2	80.8	167.9	238.1	278.8	299.7	314.6	331.1	1,396.0	1,727.1
Savings as a % of Status Quo	4%	19%	38%	51%	58%	60%	60%	60%	43%	45%

Source: Northern Economics, Inc. estimates.

In 2021, the first full year of operations, the savings are approximately $315 million or a savings from the status quo of about 60 percent. The total for the 2015 through 2021 time period is approximately $1.4 billion.

It is uncertain if or when GVEA and Flint Hills might connect to the gas distribution system, but at some point in the future if a gas pipeline is built to Fairbanks it may be more cost effective for these two firms to use the piped distribution system rather than continue to truck LNG from the North Slope. While the industrial firms could benefit from being connected to the distribution system, residential and commercial customers could benefit from the greater throughput, which reduces the fixed costs per unit.

Switching to natural gas or propane only occurs when the cost of the gas or propane and the estimated conversion cost are equal to or less than 90 percent of the price of fuel oil adjusted for average oil-fired appliance efficiency, or 110 percent of the cost of wood adjusted for average wood stove efficiency. Based on experience in Southcentral Alaska the price point to switch to gas is higher than the cost of wood due to the convenience factor.

Benefit-Cost Analysis

A benefit-cost analysis (BCA) was undertaken to provide another perspective for decision makers. The BCA focused on the cost differences between the continuation of using primarily distillate fuels and wood for heating and industrial uses, and switching to the use of natural gas and propane. A benefit cost ratio greater than one indicates that the present value of costs for the natural gas and propane alternative is less than the costs of the status quo, indicating that investment in the natural gas and propane alternative should be made. As noted in Table ES- 6 the benefit-cost ratio for the entire project is greater than one, and this ratio is greater than one for all three density areas.

Table ES- 6. Benefit-Cost Analysis Summary for Fuel and Conversion Costs

	Billions of 2012 $		
Alternative	Present Value of Costs	Present Value of Cost Savings	Benefit-Cost Ratio
Status Quo	**10.62**	**--**	**--**
High Density Area	7.10	--	--
Medium Density Area	2.65	--	--
Low Density Area	0.86	--	--
With Natural Gas/Propane Alternative	**5.25**	**5.36**	**2.02**
High Density Area	3.27	3.83	2.17
Medium Density Area	1.46	1.20	1.82
Low Density Area	0.53	0.33	1.63

Source: Estimates by Northern Economics, Inc.

Note: Costs are discounted using a seven percent discount rate. Additional detail on the benefit-cost analysis is provided in Section 8.

Converting to natural gas and propane provides substantial savings to borough residents and businesses, and these benefits extend over all three density zones. The highest benefit-cost ratio occurs in the high-density area, where the price for natural gas is low enough to achieve high market penetration, and where development densities result in a large number of users per mile of pipeline. The lowest benefit-cost ratio occurs in the low-density zone, where propane is not priced low enough to provide an incentive for residences that use wood for heating to switch to propane, and where the price differential between propane and heating fuel is less than the price difference between natural gas and heating fuel.

The present value of costs of an alternative using natural gas and propane to meet the heating and industrial demand is estimated at approximately $5.25 billion in 2012 dollars. This amount includes the cost of the fuels, conversion costs for replacing the existing furnaces or boilers, and the capital and operating costs for the piped distribution system. This estimate also includes the cost of new propane trucks and tanks to serve the low-density area of the borough; similar to the status quo, estimated costs for the high, medium, and low-density areas of the borough are presented in the table. The $5.25 billion also assumes that the distribution system is operated by a private company, which results in a more conservative comparison since government or cooperatives would be expected to have lower costs, as discussed later in the report (see Sections 4.1 and 7).

The net present value expressed in 2012 dollars of the potential cost savings from converting to lower cost natural gas and propane is estimated at approximately $5.36 billion over the 50-year study period.

Air Quality

Project air quality engineers prepared an analysis of the potential effects on air emissions from conversion to natural gas-fired space heating systems in the residential and commercial sectors of the three zones noted earlier. This analysis estimates the annual amount of criteria pollutant emissions in each demand zone for each year of the conversion effort.

Criteria pollutants are regulated pollutants under the Clean Air Act, and include:

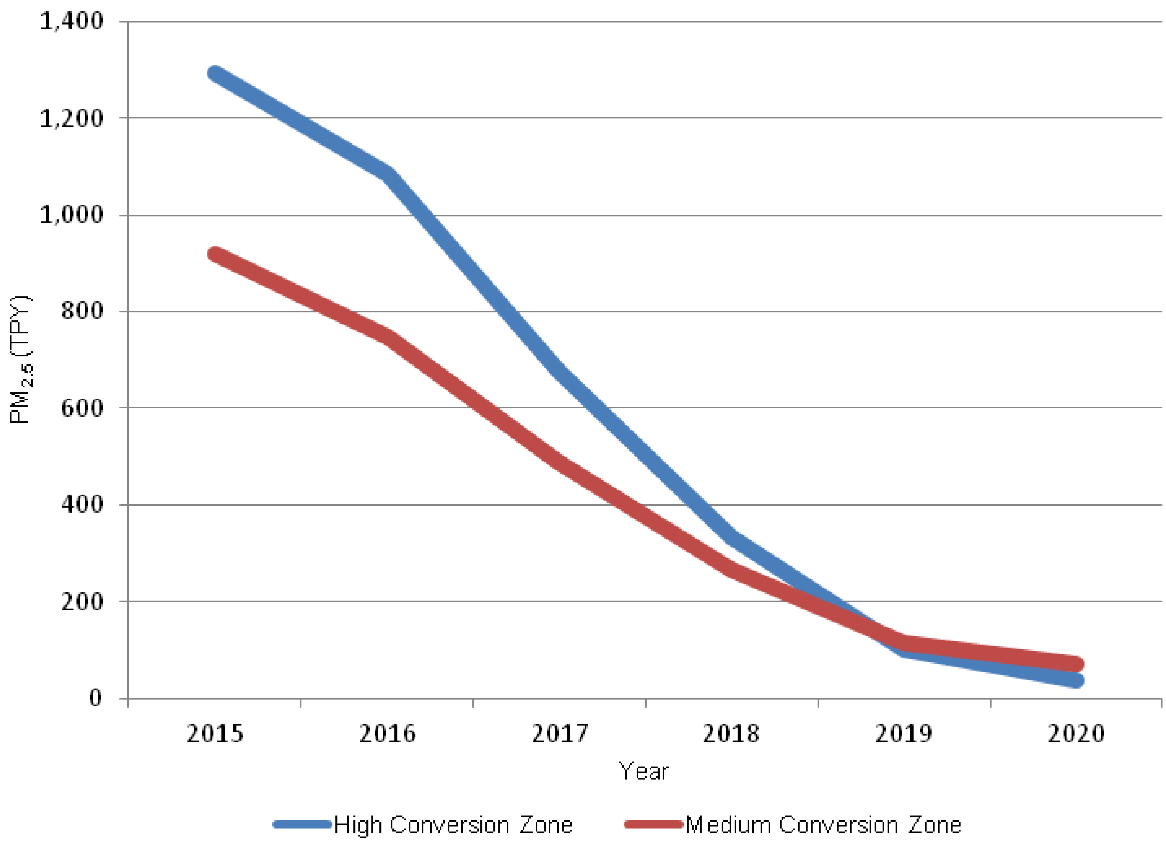
- Oxides of nitrogen (NO_X),
- Carbon monoxide (CO),
- Particles with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}),
- Particles with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$),
- Sulfur dioxide (SO_2), and
- Volatile organic compounds (VOC).

Emissions of each criteria pollutant are expected to decrease substantially based on the conversion scenarios presented in this report.

Of particular concern to the FNSB is the criteria pollutant $PM_{2.5}$, also known as fine particulate matter. The United States Environmental Protection Agency (EPA) has designated portions of the Fairbanks and North Pole areas as a nonattainment area for $PM_{2.5}$, as shown in Figure ES-1. The EPA regulates $PM_{2.5}$ because it can cause or aggravate serious health problems, including asthma, bronchitis, and heart attacks. Further, the nonattainment designation negatively affects economic growth due to air quality permitting constraints that apply in nonattainment areas.

The analysis demonstrates that converting to natural gas use for heating will reduce the overall emissions of $PM_{2.5}$ in the Fairbanks area. Figure ES-3 illustrates the estimated change in $PM_{2.5}$ emissions from residential and commercial sources in the high and medium-demand zones. Total $PM_{2.5}$ emissions decrease from approximately 2,200 tons per year to less than 200 tons per year. The analysis makes clear that conversion of residential heating systems from wood-fired and coal-fired to natural gas-fired is essential to achieving reductions in $PM_{2.5}$ emissions.

Figure ES-3. $PM_{2.5}$ Emissions Estimates, High and Medium Demand Areas, 2015 to 2020, in Tons of Pollutant per year.



Source: SLR International

The conversion to natural gas will also reduce NO_X and SO_2 emissions, which are precursors to the formation of secondary $PM_{2.5}$ in the atmosphere. These emission reductions will help bring the Fairbanks area into attainment with the ambient $PM_{2.5}$ air quality standard.

The emissions reductions presented here reflect the changes associated with the piped natural gas systems in the high and medium-demand areas or propane systems in the low-demand area. Emissions from facilities in the industrial sector, as described in Section 2, are not included in this analysis.

If the Fairbanks area converts many of the existing space heating emission units to natural gas combustion, water vapor emissions will likely increase. These additional water vapor emissions do not necessarily mean that ice fog events will become more common because the frequency of the meteorological conditions that trigger ice fog events will not increase. However, the ice fog events that do occur may have slightly longer duration and may cover a slightly larger geographic area.

Decision Points

The purpose of this report section is to identify if there were zones or areas where the costs of converting to natural gas and propane were greater than the costs of using distillates and wood. As noted in the BCA discussion (Section 8), the benefit-cost ratio for each of the three density areas (high, medium, and low) is very positive, so there is no need to phase the project or to not undertake development of the distribution system in any area.

However, the model indicates that wood switching will not occur in the high and medium density areas for several years depending on the specific model assumptions that are used. In most model runs the wood switching does not occur until 2021 or so, when the volume of gas sales has increased to the point where the fixed costs can be spread across greater gas sales volumes. Substantial increases in the amount of grants to the project can move the switching date to an earlier year. Another approach could be to obtain grants that could be used as operating funds and employed to reduce the sales price for the first five or six years until the conversions are generally complete or the sales volumes enable gas to compete with wood.

The model also indicates that propane can displace fuel oil in the low density area but is unlikely to cause residents using wood heat to switch to propane. This outlook may not be an issue since there are relatively few structures in the low density areas and they are widely dispersed. However, it does mean that this group may not benefit from the energy investment available to other residents.

1 Introduction

In November 2011, the Fairbanks North Star Borough (FNSB) solicited proposals from consulting teams to develop an optimized plan for a rapid build-out of the borough's energy distribution infrastructure, and to assess the effect of the build-out on air quality in the FNSB's $PM_{2.5}$ nonattainment area.[1] Northern Economics, Inc. assembled a team of engineers, air quality specialists, and experienced natural gas utility managers and submitted a proposal in December.

1.1 Project Goals

The FNSB set two overarching goals for the project:

- To define a supply-neutral optimized plan for the rapid built-out of the FNSB's energy distribution system—one that delivers propane or natural gas as affordably as possible, to the largest number of borough residents, businesses, and business and residential properties.
- To assess the impact of the proposed infrastructure build-out on air quality in the FNSB nonattainment area.

1.2 Major Findings

Construction and operation of a piped natural gas distribution system in the high-density and medium-density areas of the FNSB (See Figure 2), and a traditional propane distribution system in the low-density areas of the borough, has the potential to reduce fuel costs for space heating of residential and commercial structures from approximately $524 million in 2021, the first full year of operations, to about $210 million, a savings of roughly $315 million annually (See Table ES-5.), a savings of 63 percent compared to the status quo using fuel oil and wood. These estimates will change with different assumptions or if capital costs or commodity costs change, but the magnitude of the savings is so large that it is evident that substantial savings will accrue under almost any future scenario that employs natural gas and propane.

Similarly, converting to natural gas for space heating will reduce the overall emissions of $PM_{2.5}$ in the Fairbanks area by a significant amount (See Figure 22). The conversion to natural gas will also reduce NO_X and SO_2 emissions, which are precursors to the formation of secondary $PM_{2.5}$ in the atmosphere. Combined, these emission reductions will help bring the Fairbanks area into attainment with the ambient $PM_{2.5}$ air quality standard.

1.3 Report Organization

The initial work product was a Preliminary Executive Summary Report, which provided an outline for the report as a whole, summarized initial results, and prepared order of magnitude market demand and gas distribution costs. The Preliminary Executive Summary Report was submitted in January; this document expands upon that initial outline to provide the full report.

[1] The nonattainment area is a designated area in which certain air quality standards are exceeded a specific number of days per year. The FNSB has a nonattainment area for particulate matter 2.5 microns or smaller in size.

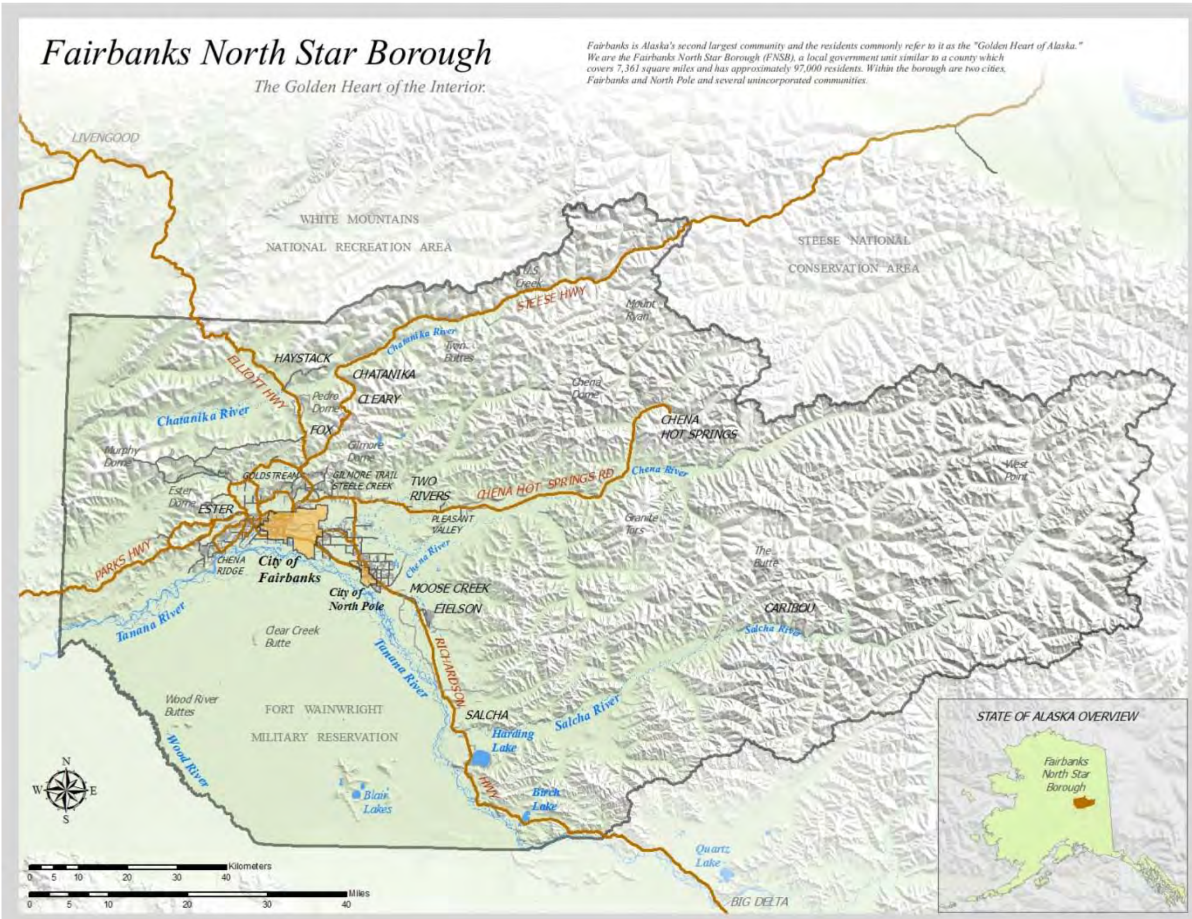
This report is organized into 12 sections:

Section 1	Introduction: Describes project goals, background for the project, and maps.
Section 2	Market Estimates: Discusses demand estimates for natural gas and propane.
Section 3	Conceptual Design: Describes transmission and piping layout.
Section 4	Business models: Discusses such options as private firms, government ownership, or cooperatives.
Section 5	SWOT Analysis: Examines strengths, weaknesses, opportunities and threats of potential organizational structures.
Section 6	Cost of Service, Financial Analysis: Provides estimates of the gas cost to consumers, sustainability of the gas distribution entity, and a benefit-cost analysis.
Section 7	Consumer Savings: Discusses savings to consumers from conversion to natural gas.
Section 8	Benefit-Cost Analysis: Shows estimated cost savings to residential, commercial, and industrial users from the conversion to natural gas from other fuels.
Section 9	Contingencies: Examines major issues that could delay (or accelerate) the potential project.
Section 10	Air Quality: Discusses the issue of $PM_{2.5}$ and how increased use of natural gas could affect air quality.
Section 11	Decision Points: Discussion of decision points regarding conversion by zone.
Section 12	References: Provides a list of works cited for this report.

1.4 Study Area

The study area encompasses all of the FNSB which is shown in Figure 1.

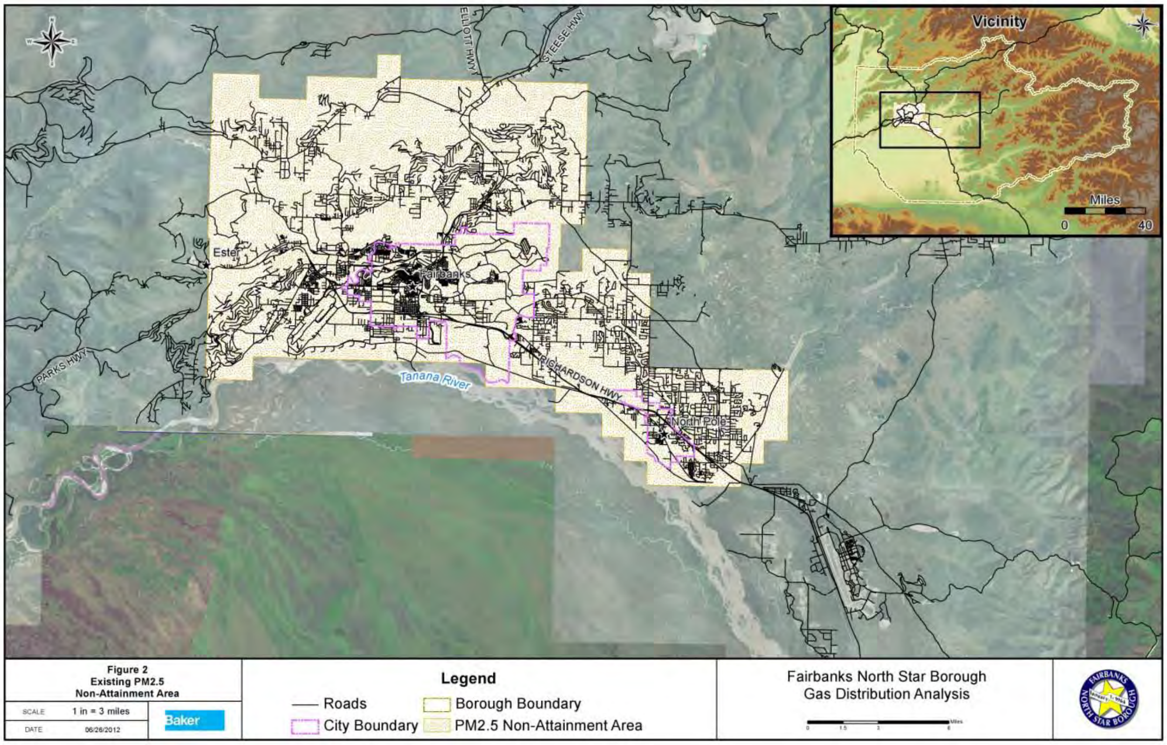
Figure 1. Overview, Fairbanks North Star Borough



Source: FNSB, 2011b.

The borough's air quality nonattainment area is shown as the $PM_{2.5}$ area in Figure 2. This is the area where 2.5 micron and smaller particles exceed the United States Environmental Protection Agency (EPA) air quality standards. Boundaries for the City of Fairbanks and the City of North Pole are also shown in the figure.

Figure 2. Fairbanks North Star Borough $PM_{2.5}$ Nonattainment Area



Source: Michael Baker, Jr. Inc, adapted from FNSB GIS Maps

2 Market Estimate

This section provides a revised estimate of the market potential for natural gas or propane within the entire FNSB jurisdiction. This market size (demand) is defined in terms of annual natural gas or propane consumption for space and water heating, power generation, and industrial processing for structures and entities located within the borough's geographic jurisdiction. The market demand estimates are used to size the gas transmission line and other facilities, and they are also key inputs to the financial, benefit-cost, and air quality analyses.

It is common convention for utilities to sell natural gas by volume (cubic feet). However, heating demand is expressed in units of energy (British thermal units, or Btu). This analysis uses a conversion rate of 1,000 Btu per cubic foot of natural gas. Propane is also sold by volume, but is conventionally measured in gallons, with each gallon providing 91,333 Btu of energy. Energy demand for propane is expressed in cubic feet equivalents in this section so that multiple units are not required.

An in-depth review of the GIS database which provides information on the number and size of residential and commercial structures within the FNSB jurisdiction, and estimates of heating loads per type of structure, it is estimated that the market potential for natural gas is 20.5 Bcf per year or an average of 56 MMcfd.

Table 1 provides the estimated annual residential, commercial, and industrial sector demand for natural gas in the FNSB region. The total potential demand represents an energy estimate in numbers of Bcf per year of the total natural gas requirements for:

- Space heating of existing residential, commercial and specific industrial structures, including non-private structures
- Power generation assuming conversion of Golden Valley Electric Association's existing 60 megawatt (MW) combustion unit from burning naphtha to burning natural gas
- Processing needs of the existing refineries in North Pole.

Table 1. Estimated Annual Residential, Commercial, and Industrial Sector Natural Gas Requirements for Heating, Power Generation, and Industrial Processing

Category	Count (# of units)	Area (square feet)	Demand (Bcf/Year)
Residential Sector	25,651	58,431,707	6.4
Commercial Sector			
Taxable Structures	2,447	21,816,488	5.6
Non-Private Structures	136	4,754,085	0.6
Industrial Sector			
Power Generation			3.1
Refinery Processing			4.8
Total	28,234	85,022,003	20.5

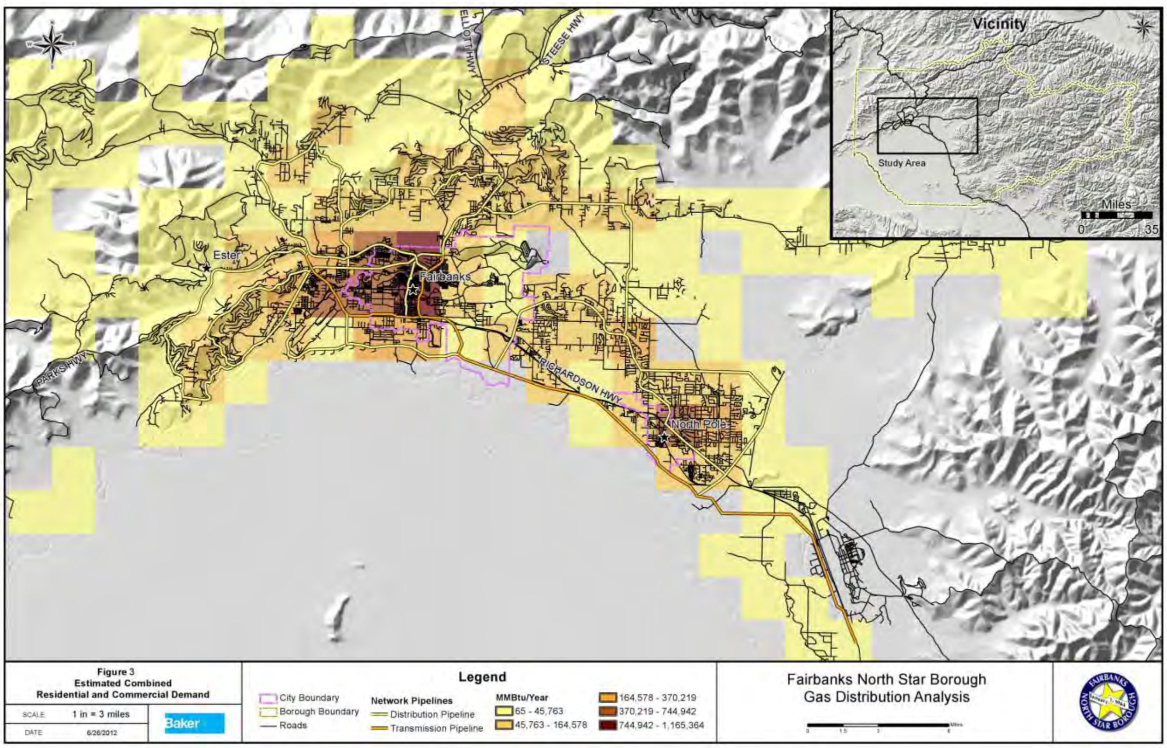
Source: Michael Baker, Jr. and Northern Economics, Inc., adapted from FNSB Property Database.

These estimates were derived using the FNSB Assessing Department's database, which has information on existing taxable structures within the borough; secondary data to determine potential load of non-private structures; and data on potential industrial energy requirements obtained from interviews and published sources.

Note that the total potential natural gas demand for the residential and commercial sectors represents 100 percent market penetration. The probability of conversion to natural gas use for heating and the timing of conversion is incorporated into the benefit-cost analysis (Section 8). Potential future demand and growth in the existing loads are also quantified and discussed in Section 8

Figure 3 shows the estimated heat loads for residential and commercial structures within the borough, based on structural square footage, a key indicator of heat loss and actual (total) heat load, as shown in the prior table, expressed in millions of Btu (MMBtu)/year.

Figure 3. Fairbanks North Star Borough, Residential and Commercial Structural Area



Source: Michael Baker, Jr. Inc., FNSB data files

Market penetration for natural gas in the region has been limited to date due to supply constraints, as ready access to Cook Inlet natural gas has been increasingly challenging. Natural gas in the form of liquefied natural gas (LNG) is currently being transported approximately 300 miles by truck from Point MacKenzie (located west and south of Wasilla) to an LNG storage and liquefaction facility in Fairbanks.

The existing natural gas distribution infrastructure in Fairbanks serves the heating needs of approximately 1,120 residential and commercial customers within the city. As reported in the FNSB's Community Research Quarterly for fall of 2011, Fairbanks Natural Gas (FNG) has 463 residential customers, 622 small commercial accounts, and 34 large commercial customers (Fairbanks North Star Borough, 2011).

In early 2012, the FNSB Assessor's property database identified 28,098 taxable residential units and commercial structures within the borough's jurisdiction. In addition, there are 136 schools and government buildings (non-private structures) that are not listed on the Assessor's database. Combined, there are 28,234 residential and commercial structures within the borough's jurisdiction (see Table 1). Fewer than five percent of the existing residential and commercial sector units are supplied with natural gas for their heating requirements. In terms of volume, in 2011 FNG sold 841,288 thousand cubic feet (Mcf) of natural gas to all its customers (2011 FNG report to Regulatory Commission of Alaska [RCA]). This volume represents about 7 percent of the total estimated natural gas requirements of the existing residential and commercial structures in the borough.

Most residential and commercial customers in the borough use heating oil for space heating and domestic hot water, though some use propane, wood, or coal. There are a number of coal-based power generation facilities in the region including those that serve the university and the military bases. Golden Valley Electric Association (GVEA), which is the largest power utility in the region, generates power locally using oil, naphtha, and coal. In the core downtown area, Aurora Energy, LLC operates a coal-fired power plant, a system that also provides steam and hot water to approximately 165 customers along four district heating loops (three are hot-water and one is steam).

Access to natural gas and expansion of the existing natural gas distribution infrastructure are necessary in order for the market for natural gas to grow. Environmental concerns related to EPA's designation of much of the borough's residential and commercial sectors as a nonattainment area for $PM_{2.5}$ provide impetus for switching from oil, wood, and coal to natural gas for space heating. Air quality issues are a major concern and economic development in the non-attainment area is currently constrained by potential additional emissions. These issues are addressed in Section 10.

This estimate of market potential for natural gas is the initial step to arrive at the probability-based demand for natural gas in the FNSB. The next step (Section 2.5) removes the demand for customers served by FNG and Aurora Energy, demand from GVEA and Flint Hills, and recreational or seasonal cabins to arrive at the total demand that may be served by a new or an expanded natural gas distribution company. In the third and final step (Section 2.7), a probability-based spreadsheet incorporates the planned construction schedule, conversion costs, potential natural gas prices to the consumer, population change, and other factors to determine annual market demand over the study period (2012 to 2065). This information is also used in the financial analysis and the benefit-cost analysis.

The following sub-sections provide more details on the estimates of the current natural gas demand for the residential, commercial, and industrial sectors, respectively.

2.1 Residential Sector

Residential sector consumption refers to natural gas used in private dwellings (including multi-residential units or apartments) for heating, air conditioning, cooking, water heating, and other household uses.

It is estimated that 6.4 Bcf per year or an average 17.5 MMcfd of natural gas will be required to meet the heating requirements of existing residential structures in the borough. The FNSB Assessor's database identified 25,651 residential units within the borough's jurisdiction, including all the structures identified as: 1) Residential; 2) Resi-Condo; 3) Multi-family; 4) Mobile Home; and 5) Trailer Court.

Of the roughly 25,651 residential structures, only 463 are being served by FNG. (FNSB 2011a) In other words, fewer than two percent of the existing residential structures in the borough are being served by the current FNG distribution system.

Table 2 summarizes market information for the Residential Sector. The estimates include residential customers that already use natural gas for heating (FNG customers) and all the other potential customers classified as residential structures in the Assessor's database. No assumption regarding the number of these residential structures that would convert to natural gas has been incorporated in these estimates, though changes due to conversion, location, and cost are addressed in other report sections.

Table 2. Residential Sector: Number of Units, Area, and Estimated Natural Gas Requirements

Category	Total
Number, parcels	25,651
Area, lots, number of acres	90,716
Area, total building square footage	58,431,707
Area, average building square footage	2,278
Natural Gas Requirement per day (average MMcfd)	17.5
Annual Natural Gas Requirement (Bcf)	6.4

Source: Michael Baker Jr. and Northern Economics estimates.

The estimated residential sector load was derived using the following information:

1. Number and area (in square footage) of all taxable, including "exempt" residential structures (such as church residences) identified in the FNSB Assessor's database;
2. Average base and heating loads as shown in Table 3. Base heating loads consist of natural gas consumed during summer months, with virtually no space heating requirements.

Table 3. Average Base and Heating Loads in Thousand Cubic Feet (Mcf) per Year by Size of Residential Structure

Size Range (Square Footage)	Count (# of structures)	Base Load (Mcf/Year)	Heating Load (Mcf/Year)	Total Load (Mcf/Year)
0 to 499	1,120	15	48	64
500 to 999	2,777	31	97	127
1,000 to 2,499	12,871	48	151	199
2,499 to 5,000	8,192	77	241	318
5,001 to 419,000	691	287	861	1,148

Source: Michael Baker Jr. and Northern Economics estimates; FNSB property database.

Notes:

1. The loads are based on ENSTAR's natural gas consumption data for Anchorage structures adjusted for Fairbank's heating degree days.
2. For large residential structures (greater than 5,000 square feet), total base and heating load were estimated using a per square foot factor of 0.13 Mcf per year. Out of the total 25,651 residential structures, the database identified 691structures that are greater than 5,000 square feet in size.

According to FNG data provided in 2009, their residential customers on average consumed about 190 Mcf per year (Northern Economics, 2010). At that time, total residential sector consumption was about 64,000 Mcf per year. In comparison, the average estimated load across the range of sizes shown in Table 3 is approximately 250 Mcf per year. For structures less than 5,000 square feet, the average estimated load is about 225 Mcf per year.

Without any information regarding the size of residential structures currently served by FNG, it is difficult to compare the results from this study with the 2009 data on average FNG residential sector consumption. The approach used in this study to determine base and heating loads relies on estimated average natural gas consumption for a specific range of home sizes. It is possible that the lower average consumption by FNG customers is due to a smaller average home size in the area that is currently served by FNG, compared to the average home size for the entire FNSB area.

2.2 Commercial Sector

Commercial sector consumption generally refers to gas used for heating by establishments primarily engaged in the sale of goods and services such as hotels, restaurants, wholesale and retail stores, and other service enterprises. For the purpose of this study, local, state, and federal government agencies, as well as schools (collectively referred to as non-private entities) are also included in the Commercial Sector category.

As shown in Table 4, the estimated commercial sector heating requirement is 6.2 Bcf per year or an average of 16.9 MMcfd. This heating and base load estimate includes commercial customers that are already being served by FNG, as well as the potential commercial sector customers within the borough's jurisdiction that could convert to natural gas.

Table 4. Commercial Sector: Number of Units, Area, and Estimated Natural Gas Requirements

Category	Total
Number, parcels (taxable)	2,447
Area, lots, number of acres (taxable)	6,688
Area, average building square footage (taxable)	5,078
Area, total building square footage	
Taxable structures	21,816,488
Non-private structures[1]	4,773,808
Natural Gas Requirement per average day (MMcfd)	
Taxable structures	15.2
Non-private structures	1.7
Total	16.9
Annual Natural Gas Requirement (Bcf)	
Taxable structures	5.6
Non-private structures	0.6
Total	6.2

Source: Michael Baker Jr. and Northern Economics estimates, based on FNSB property database and load data provided by ENSTAR.

[1] Note: This value is the sum of square footage for 136 non-private facilities located within the Fairbanks North Star Borough, excluding 16 facilities that are owned by the City of North Pole for which there are no square footage data. Natural gas requirements for the City of North Pole facilities were estimated using actual heating oil consumption in 2010.

The commercial sector's potential natural gas requirements were estimated using the following information:

1. Area (in square feet) of all commercial structures identified in the FNSB Assessor's database (taxable structures);
2. Area (in square feet) of the non-private facilities—including schools, federal and state office buildings, and facilities owned by the City of Fairbanks. The data for the state-owned facilities in Fairbanks were obtained from the Alaska Department of Transportation and

Public Facilities; data for the City of Fairbanks facilities were provided by the City's Property Manager; data for the schools and borough-owned facilities were provided by the borough's Project Manager, Director of Public Works; and data for the federal buildings were obtained from General Services Administration's Operations Manager;

3. Data on base and heating load per square foot for specific types of commercial customers.

ENSTAR provided information on actual natural gas consumption for various types of businesses listed in their database of Anchorage customers. Examples include natural gas requirements for facilities such as government buildings, malls, retail stores, schools, parking garages, warehouses, office buildings, museums, and dry cleaning facilities. The estimated natural gas consumption for specific types of facilities was provided on a per-square-footage basis. This per-square-foot load estimate was then multiplied by the square footage data as noted in items 1 and 2. Finally, the load was further adjusted upward to account for the difference in the heating degree days between Anchorage and Fairbanks. This methodology was used to derive heating requirements for 2,447 taxable and 136 non-private structures.

There are 16 facilities that are owned by the City of North Pole for which actual fuel (heating oil) consumption data were provided; square footage data were not available. The data were obtained from the Director of City Services for the City of North Pole. For these facilities, potential natural gas requirements were estimated using the equivalent Btu content of heating oil.

The estimated natural gas requirements for Fairbanks Memorial Hospital were obtained from previous estimates provided by FNG as published in the Interior Issues Council Report (In-State Gas Pipeline Supply Options Study, 2009).

Note that FNG currently already serves 622 small commercial customers and 34 large commercial customers, a total of 656 commercial customers. (FNSB 2011a)

There are 2,447 commercial establishments identified in the Assessor's database and an additional 136 non-private structures identified during this research. These numbers imply that roughly 25 percent of the current commercial sector market for natural gas is already being met. It should be noted, however, that there may be other non-private structures that may have been missed in the attempt at an inventory of non-private facilities.

As expected, market penetration in the commercial sector is higher compared to the residential sector. Economies of scale with respect to conversion costs are achieved with the commercial establishment's higher heating loads.

2.3 Industrial Sector

Industrial sector consumption refers to two types of natural gas use—fuel for electricity generation and fuel for industrial processing needs. The estimate of the total industrial sector demand for natural gas is about 7.9 Bcf per year, or an average of 21.7 MMcfd. This amount represents the estimated industrial sector natural gas requirements. However, GVEA and Flint Hills are proposing to liquefy and transport LNG from the North Slope direct to their facilities. Hence, the amount of natural gas they would require is not expected to be part of the volume that would be transported through the natural gas distribution system (See Section 2.5).

Note that it is unlikely that existing facilities that use coal for heating and power generation would switch to natural gas in the near future. These existing coal-based facilities include Eielson Air Force Base, Fort Wainwright, Aurora Energy, and the Central Heat and Power plant at the University of

Alaska Fairbanks.[2] If these facilities convert to natural gas, it is estimated that they will require about 9 Bcf of natural gas per year. However, this potential demand is not included in the total estimated industrial sector demand of 7.9 Bcf per year but the conceptual design of the natural gas transmission lines does allow for these coal-based facilities to be served in the event that they convert in the future.

2.3.1 Electricity Power Plant Load

Power sector demand is estimated to be about 3.1 Bcf per year. Unlike the residential and commercial sectors, the estimated demand for the power sector only represents a portion of the total power sector market. The demand estimate reflects 20 percent of the total existing generation capacity of GVEA.

GVEA is the primary utility that provides electricity in the region and it utilizes a diverse mix of fuel including oil, naphtha, coal, natural gas, and hydroelectric. The utility serves about 44,000 customers in the Fairbanks, Delta Junction, Nenana, Healy, and Cantwell areas.

The GVEA combustion turbine (GT3) at their North Pole facility is the most likely to convert to natural gas (IIC, 2009). The GT3 is a 60 MW LM6000 combined cycle unit that currently fires naphtha, a clean burning fuel, produced at the Flint Hills refinery located nearby. Based on current data provided by GVEA, the GT3 unit consumes 24.2 million gallons of fuel per year. Given a heat content of 127,500 Btu per gallon of naphtha, the estimated natural gas requirement for GT3 is about 3.1 Bcf per year.

Note that the steam turbine generator at the North Pole expansion facility is double-sized to prepare for a possible power plant expansion. Adding another 60 MW of generating capacity could double the power sector natural gas demand to 6.2 Bcf per year. Furthermore, the original 120 MW capacity North Pole plant that has the GT1 and GT2 units could also be retrofitted with natural gas. However, currently there are no plans to retrofit these units to natural gas due to design issues.

2.3.2 Industrial Processing Load

The estimated load for industrial processing refers to the natural gas requirements of the two existing refineries in the region.

Flint Hills Resources' North Pole refinery is located southeast of Fairbanks in North Pole. The refinery is the largest in Alaska with a crude oil processing capacity of 220,000 barrels per day. The facility consumes about 64,000 barrels of North Slope crude oil per day to produce various petroleum products including gasoline, jet fuel, heating oil, diesel fuel, gasoil and asphalt for supply to Alaska markets. The refinery uses a portion of the crude stream to fire boilers and the distillation tower for the production of liquid fuels. (IIC 2009)

The Petro Star refinery is also located in North Pole. This refinery has a capacity of 22,000 barrels per day, producing kerosene, diesel, and jet fuels. The refinery uses both crude oil and non-condensable gases to fuel its crude oil refining process. (IIC 2009)

Both refineries are expected to switch to use of natural gas to meet their processing needs. It is estimated that the two refineries will require a total of 4.8 Bcf of natural gas per year or 13.2 average MMcfd for their processing needs. However, as noted earlier, Flint Hills and GVEA are expected to meet their needs independent of the natural gas distribution system.

Note that Flint Hills Refinery recently announced that it will be closing its No. 1 crude oil refining unit due to challenging economic conditions faced by the refinery (Alaska Journal of Commerce,

[2] Note that the Central Heat and Power Plant at UAF also uses some natural gas and oil besides coal for generation of power and heat.

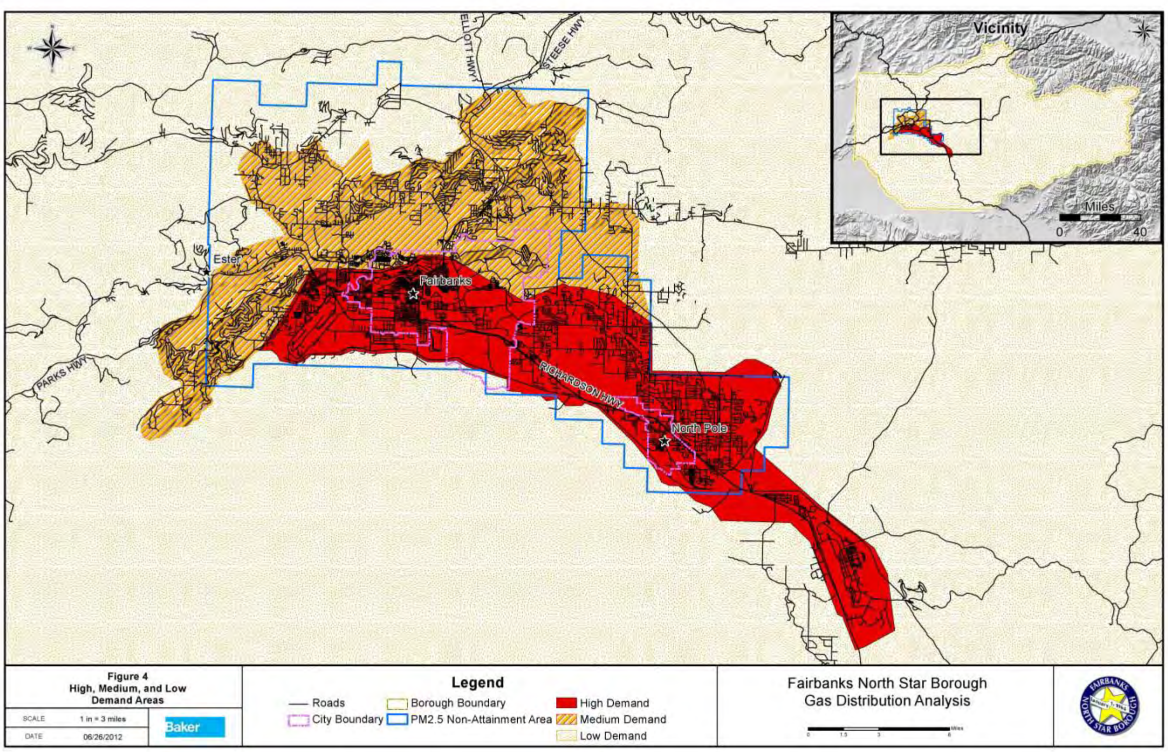
April 2012). The company will continue operating its remaining No. 2 crude unit to produce jet fuel, gasoline, asphalt, and other products to meet all its contractual commitments. The company noted that the refinery faces the problem of burning crude oil, which is costly at current prices, to provide energy for its refining operations. This study assumes that availability of cheaper natural gas in the future would bring the refinery operations back to 2011 levels.

In summary, the total industrial sector load is estimated to amount to 7.9 Bcf per year or an average of 21.7 MMcfd—3.1 Bcf per year for power generation plus 4.8 Bcf per year for refinery processing. If the coal-based power and heat facilities were to convert to natural gas, the potential natural gas requirement will increase by 9 Bcf per year, to a total of 16.9 Bcf per year.

2.4 Low, Medium, High Demand Borough Areas

Figure 4 displays the three demand zones within the FNSB, along with the boundary of the $PM_{2.5}$ zone of non-attainment. The demand zones were created based on the density of development within the borough as identified through a geographic information system analysis, and the corresponding demand estimates for different structure types. The high-demand area is colored red, the medium-demand is noted with orange diagonal lines, and the low demand-area is the outlying area.

Figure 4. Map of Fairbanks North Star Borough with Three Zones of Demand



Source: Michael Baker, Jr. Inc, adapted from FNSB GIS Maps

Pipeline construction for the high demand area is assumed to be completed by September 2015. However, residential and commercial sector conversion from heating oil is anticipated to occur over a period of five years; it is unlikely to achieve 100 percent market penetration in the first year that natural gas is made available. For the medium-demand area, construction is assumed to be finished by September 2016 with ongoing conversion similar to the high-demand area. Homes and commercial buildings in the low-demand area are assumed to continue to use existing energy supplies, such as fuel oil, propane, or wood. The potential for air-propane and compressed natural gas is discussed in Section 3.4.

Table 5 summarizes the natural gas requirements (in Bcf per year) of the residential, commercial, and industrial sectors in the low, medium, and high demand areas.

Table 5. Estimated Natural Gas Requirements in the High, Medium, and Low Demand Areas by Category

	High Demand	Medium Demand	Low Demand	Total
Category	Bcf/Year			
Residential	**3.27**	**2.28**	**0.84**	**6.38**
Commercial	**5.58**	**0.43**	**0.16**	**6.18**
Taxable Structures	5.06	0.34	0.16	5.56
Non-Private Structures	0.52	0.09	0.01	0.61
Industrial	**7.90**	**0.00**	**0.00**	**7.90**
Power Generation	3.1	0	0	3.1
Refinery Processing	4.8	0	0	4.8
Total	**16.75**	**2.71**	**1.00**	**20.46**

Source: Michael Baker Jr. and Northern Economics estimates.

2.5 Adjusted Natural Gas Demand

The sections above presented the estimated natural gas requirements of the residential, commercial, and industrial sector in the region. The results indicated that the total market potential for natural gas in the region is approximately 20.5 Bcf per year assuming that all residential and commercial structures in the region would use natural gas for space heating and other base load requirements (e.g., cooking, water heating), and that the estimated industrial sector load will be transmitted through the expanded local distribution system. It is unlikely, however, that this total market potential will be realized as soon as natural gas becomes available in the region. Rather, it is more likely that penetration of natural gas in the total energy market in the region will vary by sector depending on factors such as the economics of conversion.

This section presents the adjusted market demand for natural gas in the region, this time making adjustments to account for the following:

1. Natural gas use by FNG customers. FNG currently has 463 residential customers and 656 commercial customers. Since FNG customers already consume natural gas, the total market potential is reduced by current consumption of natural gas in the region (already existing). In 2011, FNG sold 841,288 Mcf (or 0.84 Bcf) of natural gas to its residential and commercial customers (FNG's 2011 RCA filing), the adjusted market demand for natural gas therefore takes into account this amount.
2. Energy consumption by Aurora Energy customers. This study assumes that Aurora Energy will continue to use coal to generate energy to support its existing steam heat and hot water heat customers. Aurora customers are also assumed to remain Aurora customers and not switch to natural gas for their energy requirements. Currently, Aurora Energy has 47 residential customers and 133 commercial customers, all of which are located in the high-demand zone. Given the estimated annual average natural gas requirements for residential

and commercial customers, the annual market potential for natural gas is adjusted by approximately 350,000 Mcf per year (or 0.35 Bcf per year).

3. Industrial sector consumption. Flint Hills and Golden Valley Electric Association are currently working on a project that will bring liquefied North Slope gas to the Fairbanks North Star Borough for use in power generation at the GVEA power plant and processing at the Flint Hills refinery in the North Pole. The proposed project is expected to deliver natural gas directly to the power plant and the refinery. This study therefore assumes that these entities' natural gas requirements (as discussed in the previous section) will not be part of the initial volume of natural gas that will be distributed through the expanded local distribution system in the region (as envisioned in this study). The annual market potential for natural gas is reduced by approximately 7.6 Bcf (3.1 Bcf for GVEA and 4.5 Bcf for Flint Hills).

4. Natural gas or propane requirement for seasonal, recreational, or occasional-use housing units. The 2010 Census reported that there were 1,676 vacant housing units in the FNSB in April of 2010 due to seasonal, recreational, or occasional use. This study assumes that the majority of these units are in the low-demand area, and that these are primarily dry cabins (no running water or anything that can be destroyed by the cold since heating costs are too high in the Interior winter). Market demand is adjusted by reducing the heat demand of the 4,278 residential units in the low-demand zone by the estimated heat demand of the 1,676 vacant units.

In summary, these adjustments resulted in an estimated annual market demand of 11.5 Bcf; a reduction of 9 Bcf from the estimated market potential of 20.5 Bcf per year as shown in Table 6. The potential market that will be served by the piped distribution system is also shown in the table. The remaining volume of the adjusted market demand not served by the piped distribution system is anticipated to be serviced by propane or propane-air systems.

Table 6. Adjusted Residential, Commercial, and Industrial Sector Market Demand for Natural Gas or Propane in the Fairbanks North Star Borough

Category	Total Estimated Market Potential	Adjusted Market Demand	Potential Market Served by Piped Distribution System
		Bcf/Year	
Residential Sector	6.4	6.1	5.6
Commercial Sector	6.2	5.1	4.9
Industrial Sector	7.9	0.3	0.3
Total	**20.5**	**11.5**	**10.8**

Source: Northern Economics estimates.

Table 7 and Table 8 show the adjusted number of residential and commercial structures in the region.

Table 7. Adjusted Number of Residential Structures

Item	Count
Total Number of Residential Structures	25,651
Number of FNG Residential Customers	463
Number of Aurora Energy Residential Customers	47
Number of Vacant Housing Structures	1,676
Adjusted Number of Residential Structures	23,465

Source: Northern Economics estimates.

Table 8. Adjusted Number of Commercial Structures

Item	Count
Total Number of Commercial Structures	2,583
Number of FNG Commercial Customers	656
Number of Aurora Energy Commercial Customers	133
Adjusted Number of Customers	1,794

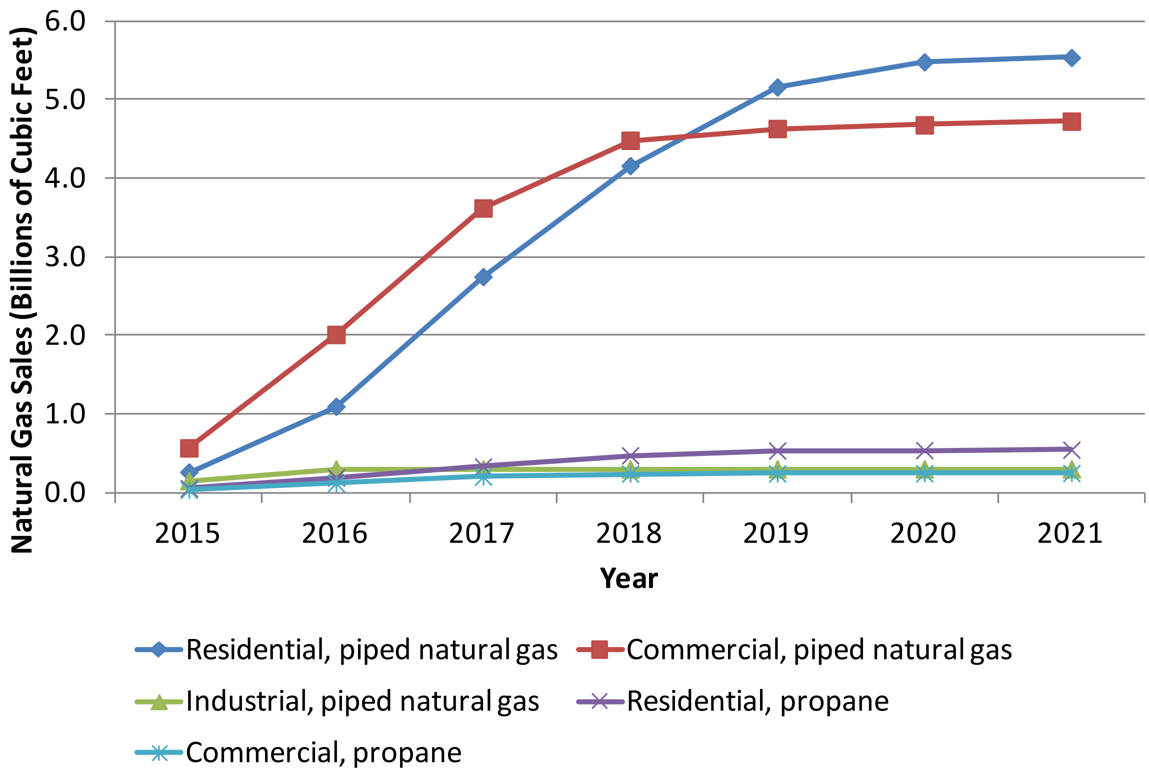
Source: Northern Economics estimates.

2.6 Projected Natural Gas and Propane Sales, 2015 to 2020

As discussed later in Section 6, the costs of natural gas and propane delivered to the consumer and the costs of conversion were compared to the costs of other heating fuels and the cost of boiler or furnace replacement on a 30-year cycle to determine if FNSB residents and businesses would switch to natural gas or propane. If the costs of natural gas and propane, plus the conversion costs were less than or equal to 90 percent of the cost of fuel oil the consumer was assumed to switch to natural gas and propane. If the costs of natural gas or propane, plus the conversion costs, were less than or equal to 110 percent of the cost of wood, the consumer was assumed to switch to natural gas or propane. The assumption that consumers would switch to a higher priced fuel in the case of wood is based on experience in the Susitna Valley when natural gas became available. Consumers switched to natural gas for the convenience factor and to avoid the disadvantages of heating with wood. In addition, a conversion rate was established for residential and commercial customers based on the experience in Southcentral Alaska.

Figure 5 shows the projected sales of natural gas and propane by user type. During initial project years, most of the change in demand is expected to be due to the adoption rate of natural gas and propane.

Figure 5. Projected Sales of Natural Gas and Propane by User Type, 2015–2021



Source: Northern Economics

Total energy demand is projected to grow about one percent annually from a starting point of about 11.4 Bcf in 2021. This growth rate generally follows increases in population and employment growth estimated by the ADOLWD.

2.7 Market Sensitivity Analysis

To account for potential variability in the assumptions used in the market demand estimates, the study used a simulation to evaluate the effect of changes in inputs on the cost of service, gas demand, benefit-cost ratio, and consumer savings. By conducting a simulation, the study team was able to determine the factors with the most impact on key outputs of the model and confirm that results of the analysis are robust given these changes.

The essence of simulation is the use of probability-based estimates and running several iterations of the model to evaluate the likely range of outcomes. The excerpt below is from the software package that the study used (Palisade Software's @RISK):

> @RISK uses a technique called "simulation" to combine all the uncertainties you identify in your modeling situation. You no longer are forced to reduce what you know about a variable to a single number. Instead, you include all you know about the variable, including its ***full range of possible values*** and ***some measure of likelihood of occurrence for each possible value***. @RISK uses all this information, along with your Excel model, to analyze every possible outcome. It's just as if you ran hundreds of thousands of "what-if" scenarios all at once! In effect, @RISK lets you see the full range of what could happen in your situation. It's as if you could

> "live" through your situation over and over again, each time under a different set of conditions, with a different set of results. [Emphasis added].

The study conducted a simulation using 10,000 iterations to gain a better understanding about significant variables and ranges of outcomes. A discussion of the simulation's findings for the cost of service is found in Section 6.3.

Variables modeled in the simulation included:

- **Distribution costs for natural gas by distribution system.** Capital expenditures ranged from $282.8 million to $606.0 million, with a most likely value of $404.03 million. As discussed in Section 6.3, distribution costs were the most significant factor in the cost of service for a private operator, and the second most significant for a government-run or cooperative utility.
- **Grant funding available for a government-run or cooperative utility.** If the gas utility were to be run by a government entity or a cooperative, it would have access to grant funding that a private company would not. The study team modeled grant funding and allowed the simulation to vary the grant based on a percentage of capital expenditures, ranging from 0 percent to 75 percent. This was the most significant factor in the price of service for a government-run or cooperative utility, as discussed in Section 6.3.
- **Percent change in the number of households by geographic service area.** Starting from 20,863 households in the high and medium areas, and 2,602 households in the low areas, in 2015, the study applied a variable growth rate (most likely of about 1.0 percent, with a range of 0.4 percent to 1.6 percent) for later years based on historic growth rates of structures in the FNSB taken from the Assessor's database.
- **Percent change in the number of commercial structures by geographic service area.** Starting from 1,705 structures in the high and medium-demand areas, and 89 structures in the low-demand area, in 2015, the study applied a variable growth rate (*most likely* was about 1.0 percent, with a range of 0.41 percent to 1.6 percent) for later years which is the same as above.

Additional factors which were kept as fixed in the model included:

- **Price of natural gas delivered to Fairbanks.** The study assumed a Fairbanks city gate price of $10.00 per million British thermal units (MMBtu) in 2015 and escalated the cost of gas of $3.51 in 2015 based on 75 percent of the annual change in the EIA's mid-petroleum price forecast for subsequent years. Other costs ($6.49 per MMBtu) were escalated at the general inflation rate.
- **Percent change in employment by geographic service area.** Employment changes are dependent on detailed cost and construction schedule that will be developed as the project is approved. More specific details are contained in Section 7 of this report.
- **Demand per residential customer by geographic service area.** The study used an average demand of 250 MMBtu per residential structure each year, based on average demand data for residential structures provided by ENSTAR and adjusted for the heating degree days in Fairbanks.
- **Demand per medium and large commercial customer by geographic service area.** The study used an average demand of 2,533 MMBtu per commercial structure each year, based on average demand data for commercial structures provided by ENSTAR and adjusted for the heating degree days in Fairbanks.

- **Industrial demand by geographic service area assuming diesel displacement.** The study kept demand level over time, at 300,000 MMBtu.
- **Start year of build-out in the Fairbanks region.** The start year was not varied. It is driven by the project's schedule and was accelerated.
- **Annual build-out rate.** The annual build-out rate was not varied. It is driven by both conversion rates and the accelerated construction schedule and is discussed further in Section 3 of this report.
- **Conversion costs.** The study did not vary conversion costs through the simulation. It developed a weighted average conversion cost per structure instead, based on a range of estimated conversion costs and an estimated distribution of system types and ages.

2.7.1 Energy Efficiency and Conservation

Energy conservation can clearly reduce residential and commercial energy requirements. As a result, in 2008, the Alaska Legislature established the Home Energy Rebate Program, to provide incentives for homeowners to retrofit homes with better insulation, new furnaces, and other improvements that generated energy savings.

According to a recent publication by the University of Alaska Anchorage Institute of Social and Economic Research (ISER), approximately 16,500 Alaskan homeowners participated in the program from April 2008 to September 2011, or about 10 percent of statewide residences (ISER 2012). The average reported spending per household was $10,963 with rebates of approximately 60 percent of that amount.

The following shows the estimated average annual savings in energy costs by type of weatherization improvement:

- More efficient furnaces, boilers — 52 percent of savings
- More insulation: walls, doors — 14 percent of savings
- Sealed air leaks — 14 percent of savings
- Replace water heaters — 6 percent of savings
- Insulation: ceiling, foundation — 10 percent of savings
- Replace, fix windows — 5 percent of savings

The ISER study suggested that the weatherization program resulted in a 15 to 20 percent reduction in fuel consumption among ENSTAR customers in Anchorage.

Fairbanks households accounted for 14 percent of all Alaska houses that were weatherized or 2,310 units. This number is approximately 13 percent of total current single-family residences in the FNSB, based on Appraiser's data (FNSB, 2012). Multiple family structures, triplexes, duplexes, cottages, cabins, and mobile homes are not included in this housing stock number.

Older homes in all regions of Alaska tended to be participants in the rebate program, likely due to less energy-efficient design and construction, especially for those homes built during the 1970s and 1980s (ISER 2012). Given the current stock of homes in the FNSB, with approximately 13,500 Fairbanks single-family homes built in the three decades from 1960 through 1980, and given that 2,310 homes already participated in the weatherization program, there could be about 10,000 or more homes that could benefit from the program and reduce energy consumption.

As natural gas distribution lines are extended through the high and medium density zones, homeowners that elect to burn natural gas could increase savings over current fuel oil costs by converting home heating and adding additional weatherization such as more insulation, tighter windows and doors, and combining hot water units with new higher-efficiency heating systems.

As noted by ISER and others, it is hard to draw a conclusion related to weatherization in Fairbanks and how it might reduce demand for natural gas. For purposes of this analysis, analysts made a simplifying assumption and used a constant demand for each type of structure, but varied the usable energy conversion rate (efficiency) from 0.85 to 0.95 for sensitivity analysis.

3 Conceptual Design

This report section provides information on the design of the pipeline distribution system, the cost estimate for the system, the schedule from design through construction, and a discussion of potential systems for the low density zone in the FNSB. Project team engineers used the demand estimates to prepare a conceptual pipeline design for the primary and discontiguous zones identified in Section 2. the prior report section.

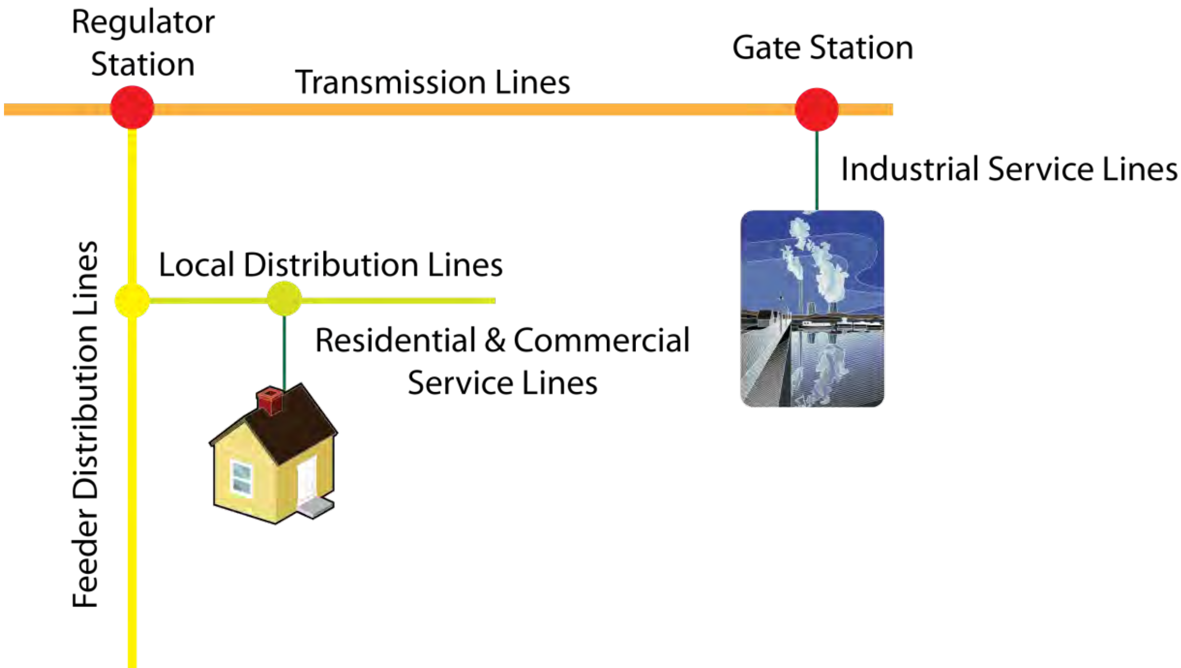
3.1 Pipeline Layout

The piped natural gas distribution system concept layout provides service to the high and medium-demand locations, which includes residential, commercial, and industrial users. The system is laid out assuming it will tie into the existing FNG distribution system. The concept system consists of the following elements:

- **Transmission lines** providing natural gas to feeder distribution lines and industrial users
- **Feeder distribution lines** providing natural gas to local distribution lines
- **Local distribution lines** providing natural gas to service lines
- **Service lines** providing natural gas to individual residential and commercial user service connections
- **Pressure regulating stations** which drop the high pressure of the transmission lines to lower service line pressure

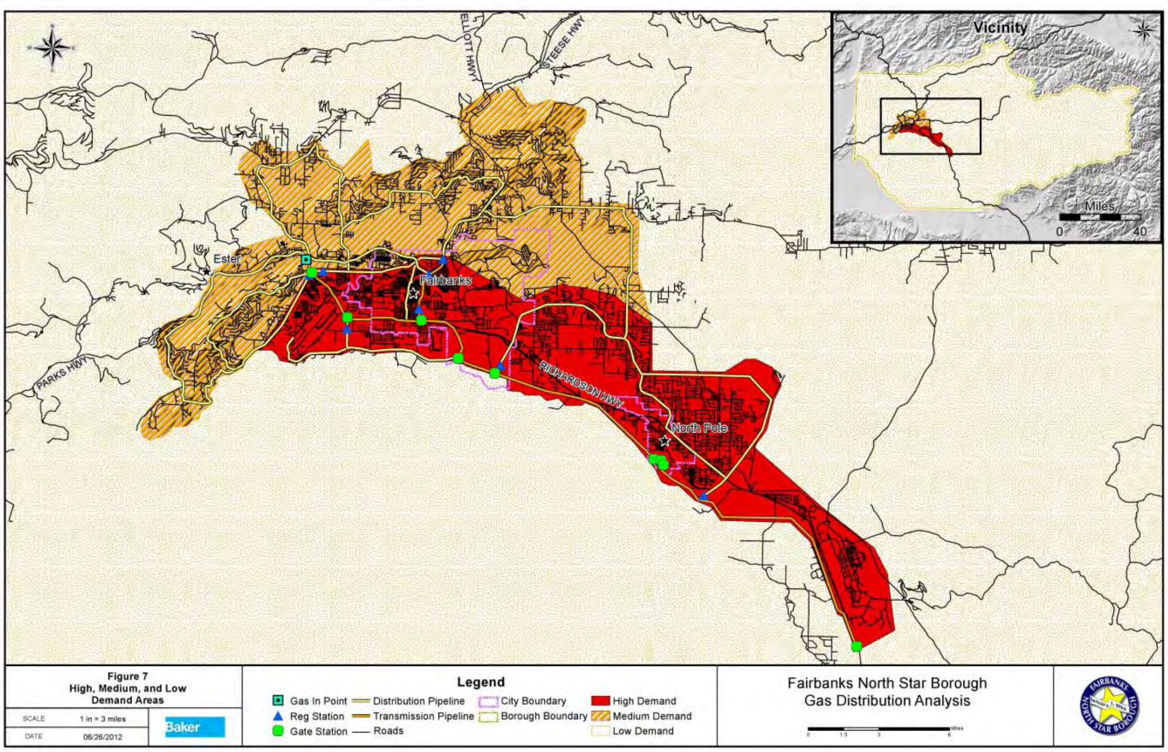
A schematic characterizing the relationship between the different types of lines is shown in Figure 6, while Figure 7 illustrates the piped natural gas distribution system layout in relation to the high, medium, and low-demand areas of the borough. Each of the system elements is described in more detail following Figure 7.

Figure 6 Schematic Pipe Relationship



Source: Michael Baker, Jr. Inc.

Figure 7. Conceptual Distribution System Layout



Source: Michael Baker, Jr. Inc.

Transmission Lines. The system includes two transmission lines. One line starts at an assumed tie-in point located west of Fairbanks near the intersection of the Parks Highway and Geist Road. The line runs southeast along the Parks Highway to the Mitchell Expressway, where it turns to the east until intersecting the Richardson Highway. It then runs southeast along the Richardson Highway for about two miles before veering south to Saddle Avenue. The line continues along Saddle Avenue until rejoining the Richardson Highway south of North Pole. The line ends at Eielson Air Force Base. A 10-inch diameter steel pipe with a total length of 31.9 miles is proposed. Future potential industrial users serviced by this line include University of Alaska Central Heat and Power Plant Coal Plant, Aurora Energy's Chena Power Plant, Fort Wainwright, PetroStar Refinery, Flint Hills Resources Refinery, and the GVEA North Pole plant. As noted earlier, with the exception of the PetroStar Refinery, none of these entities are expected to use the piped natural gas distribution system in the near term.

The other transmission line consists of an 8-inch diameter steel pipe that connects with the other transmission line at the intersection of the Mitchell Expressway and the Richardson Highway. The line runs north along the Richardson Highway and continues north along the Steese Highway until terminating at the Johansen Expressway, where it connects with two feeder distribution lines. The length of this line is estimated at 3.1 miles.

Feeder Distribution Lines. The feeder distribution lines are configured to provide service to Fairbanks and the outlying areas extending to Ester, the Goldstream Valley, and North Pole. The distribution lines run along the major roadways, including Chena Ridge Loop Road (also known as Chena Pump Road), Chena Ridge Road, Sheep Creek Road, Farmers Loop Road, Chena Hot Springs Road, Nordale Road, and Badger Road. The feeder distribution system is configured as a loop system, maintaining flow from multiple directions to minimize service interruptions. Six-inch diameter plastic pipe is proposed for the feeder distribution lines, which are estimated to total 118.2 miles of pipe.

Local Distribution Lines. The local distribution piping provides service to individual residences and commercial users. The layout is based on the local street network. Two-inch diameter plastic pipe is proposed for the local distribution lines with an estimated 804.4 miles of pipe.

Service Lines. Service lines connect individual users to the distribution system. Residential customers will be serviced with a 5/8-inch diameter plastic line. Commercial customers will be serviced with a 1-inch diameter plastic line. The estimated total is 325.3 miles of pipe.

Pressure Regulating Stations. The system uses two types of pressure-regulating stations to reduce the pressure from the transmission lines. Gate stations reduce the transmission line pressure to a user-specified pressure. Gate stations are provided for higher pressure feeder distribution lines and industrial users. Nine gate stations are proposed for the system. Regulator stations reduce the pressure from the transmission line to 60 pounds per square inch (PSI) for the lower pressure distribution and service lines. Regulator stations are located where the lower pressure feeder distribution lines connect with the transmission lines. Nine regulator stations are proposed for the system.

3.2 Initial Pipeline Cost Estimate

3.2.1 Preliminary Pipeline Cost Estimate

Table 9 summarizes the Class 4 Estimate for the piped gas distribution system. The total estimated costs range from $282.8 million to $606 million. This estimate is based on limited information and analysis (see section 3.2.2). A detailed Basis of Estimate and Cost Estimate are attached as Appendix A.

Table 9. Total Cost Estimate

Item	Estimated Cost Range ($Millions)
Phase 1, High-Demand Area	
Engineering, Permitting & ROW Services	8.1 to 17.3
Construction	153.5 to 328.9
Total	161.6 to 346.2
Phase 2, Medium-Demand Area	
Engineering, Permitting & ROW Services	5.9 to 12.7
Construction	115.3 to 247.1
Total	121.2 to 259.8
Total Phase 1 and Phase 2	**282.8 to 606.0**

Source: Michael Baker Jr. Corporation 2012

3.2.2 Basis for Initial Estimate

Total Installed Cost (TIC) estimates are developed with varying accuracy ranges at different stages in a project. For this project, with design at a conceptual level of 1–15 percent complete, the Association for the Advancement of Cost Engineering assumes an expected accuracy range of +50/-30 percent and labels it a Class 4 estimate. This initial construction cost estimate uses a factored approach. All costs are based on recent projects with similar demands. Prices have been scaled to account for differences in size, location, and constructability.

Separate estimates were developed for the Phase 1, high-demand locations (build-out in years 1–5) and the Phase 2, medium-demand locations (build-out in years 2–6). It includes major materials, installed pipe, engineering, and permitting costs. Provisions for unknown costs are included in the estimate. Unknown costs account for the uncertainty due to the lack of detailed design and project development for the current level of estimate. The unknown costs are estimated at 30 percent of the installed costs for this estimate. All costs are in 2012 dollars.

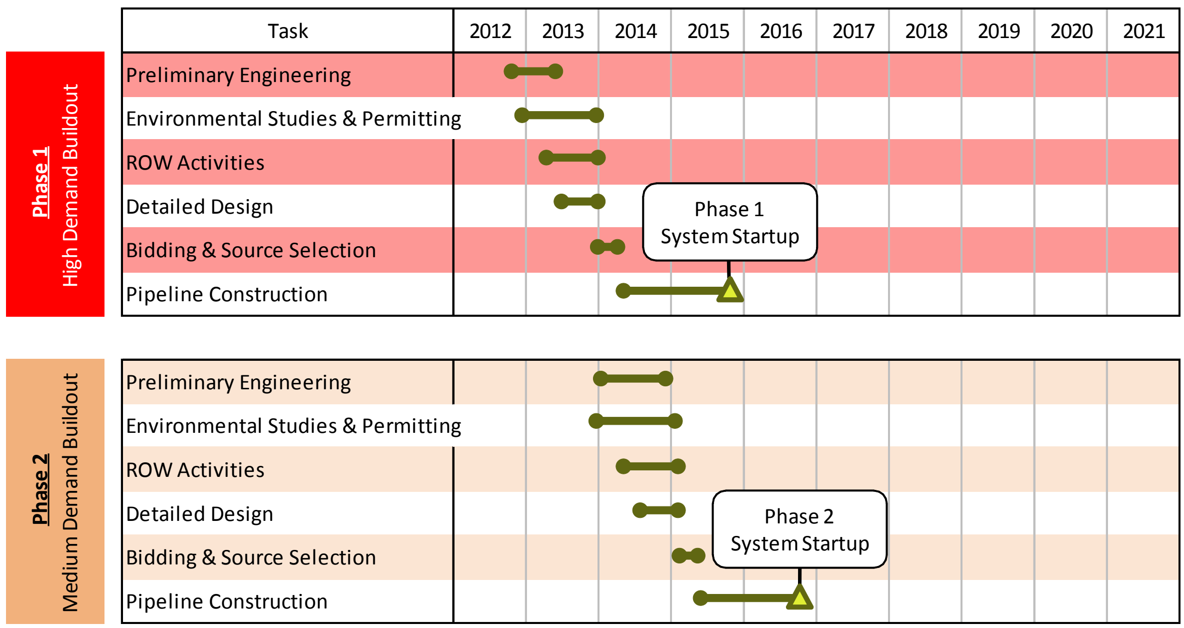
The initial estimate is composed of four elements:

1. **Transmission Lines.** This element includes the costs of installing the 10- and 8-inch diameter steel transmission pipe. Other costs covered in this element include cathodic protection, gate stations, and pigging equipment. All transmission lines will be installed during Phase 1 construction.
2. **Distribution Feeder Lines.** This includes the costs of installing the 6-inch diameter plastic distribution pipe. Regulator station costs are included in this element of the estimate. Distribution feeder lines will be installed during Phase 1 and Phase 2 construction.
3. **Local Distribution Lines.** This element includes the cost of installing the 2-inch diameter plastic distribution pipe. Distribution lines will be installed during Phase 1 and Phase 2 construction.
4. **Service Lines.** This element includes the costs of installing the small diameter (5/8 to 1 inch) plastic pipe which connect to the residential or commercial structures. Service lines will be installed during Phase 1 and Phase 2 construction.

3.3 Preliminary Development Plan and Schedule

The project development plan identifies the major tasks required to build an operational piped natural gas distribution system. Tasks include engineering, environmental studies and permitting, right-of-way (ROW) acquisition, procurement, and construction. Figure 8 shows a concept development plan schedule for the project. The schedule is broken into two phases. Phase 1 addresses the high-demand area, which is expected to be completed within the first four years. Phase 2 addresses the medium-demand area, which is expected to be completed within years two to five. For both phases, preconstruction activities such as engineering, environmental studies, permitting, ROW acquisition, and procurement are planned for the first two years. Construction and conversion activities are planned for the last three years of each phase.

Figure 8 Proposed Concept Project Schedule



Source: Michael Baker Jr. Corporation 2012

Note: Gas will flow in 2015 (Phase 1), while conversion continues.

A description of activities that occur during each major task is provided below.

Preliminary Engineering. Activities under this task will include existing data collection, concept pipeline layout, and engineering field reconnaissance. The pipe network will be modeled to determine the size of pipe needed. Field surveys and utility locates will be accomplished to support detailed design. The preliminary engineering task is expected to last approximately one year.

Environmental Studies and Permitting. Construction and operation of the gas distribution lines in the FNSB may require federal, state, and local permits. If federal permits are required, completion of the National Environmental Policy Act (NEPA) process and formal public and agency scoping may be necessary. Wetland, raptor, fisheries, and cultural resources studies may be required if information on potential effects on those resources does not exist for the project area. These studies must be conducted during the growing season. This task is expected to last approximately one year.

ROW Activities. This task will include surveying and mapping existing property boundaries and then identifying land status and ownership. Land ownership must be determined prior to finalizing the list of necessary ROW permits. Temporary land use permits from federal and state land owners may be required for staging and temporary construction areas. ROW permits, easements, or acquisition efforts will then be completed. This task is expected to last approximately nine months; it could take longer depending on the complexity of any required ROW acquisition.

Detailed Design. Detailed design will include finalizing the pipe layout, sizes, and associated infrastructure. Because of the long lead time required for fabrication, pipe and major equipment will be ordered when this task is approximately 70 percent complete. The detailed design task is expected to last approximately six months.

Bidding and Source Selection. Once the design is finalized, the project will be advertised for bid and a contractor selected. This task is expected to last approximately three months.

Pipe Distribution System Construction. Construction will begin when the required permits are in place, ROW activities are complete, and a contractor has been selected. Construction is expected to last three years.

3.4 Propane or Compressed Natural Gas Zones

Borough areas outside of the high and medium-demand zones primarily depend on fuel oil, wood, and propane for cooking and heating. For the most part, these borough areas consist of low-density neighborhoods with scattered homes and businesses. Though it is difficult to discern from the available data, wood (17.2 percent) and fuel oil (67.3 percent) appear to be the largest heating fuel sources in the low-density zone (Fairbanks Home Heating Study 2010).

As a basis of comparison, Figure 9 illustrates a high density residential area in the northwest part of the area, while Figure 10 illustrates a low density area, also on the west of Fairbanks and at the same scale as Figure 9.

Figure 9. Fairbanks North Star Borough, Gas Distribution, Representative High Density Area

Source: Google Maps, © 2012 Google, Accessed May 2012

Figure 10. Fairbanks North Star Borough, Gas Distribution, Representative Low Density Area

Source: Google Maps, © 2012 Google, Accessed May 2012

Several lower-density areas have developed as neighborhoods, and they are within the potential reach of natural gas lines when the lines are extended. However, natural gas connections cost money for transmission and distribution pipes, as well as connections from distribution pipes to homes or other buildings. Experienced natural gas utility managers in Anchorage suggest 10 to 12 service connections per mile are a target for economical operations. Fewer service connections per mile of distribution pipe, however, means greater cost per connection and higher cost per residence as capital costs are spread over fewer gas customers.

As noted, the FNSB contains pockets of more densely populated neighborhoods outside of the high or medium-density zones. Since these neighborhoods may be targets of opportunity by natural gas utilities, they can be prepared for natural gas by piping homes in the area and heating homes with mixtures of propane and air or possibly compressed natural gas (CNG). These neighborhood "pockets" exist along the Goldstream road, the Murphy Dome and Ester Dome roads, and the Old Nenana Highway.

The potential for propane and CNG use is discussed more thoroughly in the following sub-sections.

3.4.1 Propane

Current propane uses within the Fairbanks North Star Borough include cooking, heating, clothes drying, appliances (refrigerators), lighting, and recreational use (small to medium bottles for picnics, hunting trips or recreational vehicle use), consistent with similar uses in the rest of the United States.

One Fairbanks propane distributor noted a 50-mile operational radius for his firm in the Lower 48 states, but up to a 150-mile radius in Alaska, a further indication of low-density rural locations and higher delivery costs. Propane from Fairbanks is routinely dispatched to Denali National Park, Delta Junction and north to Livengood.

Propane Characteristics

Propane characteristics include:

- BTU per gallon 91,333 BTU
- Boiling point -44 degrees F
- Weight of one gallon 4.24 pounds (liquid)

One gallon of propane contains approximately 66 percent of the heat in a gallon of fuel oil, propane's primary competing fuel in the FNSB.

Winter temperatures routinely fall below boiling point temperature of -44 degrees in the borough. Solutions to keep propane flowing when this occurs include sheds or outbuildings that may be heated with electric lights or warming blankets that help insulate outside fuel tanks.

Propane-air mixtures

Propane may be mixed with air to produce a combined vapor mixture that has properties similar to natural gas. These systems draw liquefied propane gas (LPG) from a storage tank, add air with a blender and then inject the combined fuel stream into a vaporizer. Output from the vaporizer burns the same as natural gas. Figure 11 illustrates a LPG-air vaporizing system in northern Canada.

Figure 11. LPG Feed Tanks and Vaporizing Unit, Nunavut, Northwest Territories, Canada.

Source: Alternate Energy Systems, Inc., Peachtree City, Georgia, used with permission

These systems are currently used in China to provide a transition fuel while natural gas lines are being extended. Areas under development are prepared with natural gas piping and burn an air-propane mixture for up to 10 years before natural gas arrives (Alternate Energy Systems, 2012).

Pinedale, Wyoming developed a city-wide propane-air (PA) system in 1975 that currently provides energy to approximately 1,200 customers in a three-mile radius of town center (Pinedale Natural Gas, 2012). As the PA system developed, the company, Western Utilities, extended its connections several miles and connected to natural gas, switching from propane with minimum disruption in 1994. The original PA system served 200 customers over the 19 years it operated. Since converting to natural gas, the system now serves 1,200 customers. There are similar conversions pending at Wendover, Utah and Yreka, California. These examples are considered possible models for rural parts of the FNSB.

Subdivision development, with consolidated utility connections placed at the same time as roads and lots are improved for sale is an ideal candidate for a PA system. The capital costs for this piping would be spread over a larger number of lots, and these utilities would be ready for connection to a natural gas pipeline as they are extended. Until that time, PA mixes could be provided on a neighborhood basis with addition of a vaporizing unit and perhaps a storage system. However, as one FNSB resident noted, many residences in low-density parts of the borough are widely distributed with few located in subdivision-like clusters. In addition, there are a number of “dry cabins” with few if any utilities. For most residences and commercial buildings in the low density area a traditional propane system with a tank and truck delivery is the most likely scenario if propane were available at a price below that of fuel oil.

The possibility of residents in low-density areas within the FNSB switching to a propane system will be the decision of individual homeowners, based on their current heating system. As noted, fuel oil is currently more common and more cost-efficient than propane, based on prices reported by the borough in November 2011, and residents could incur several thousand dollars in capital costs to install a new propane heating system. The high cost of installation, along with higher fuel costs and lower efficiency suggest there is no short-term incentive for residents in low-density areas to switch from fuel oil to propane.

However, it seems reasonable that low-cost propane from the North Slope or elsewhere could substitute for fuel oil. Studies by ANGDA and others indicate that propane can be obtained on the North Slope at very reasonable prices compared to current prices for propane. This analysis assumes that lower-cost propane will be available from the North Slope or elsewhere in the state. Team members feel most homeowners would need at least a 10 percent reduction in equivalent heat cost before considering a switch from fuel oil. As noted earlier, the convenience factor of propane compared to wood could result in customers switching to propane if the cost were less than 10 percent higher than the cost of heating with wood.

3.4.2 Compressed Natural Gas

CNG, if available, competes with both LNG and propane. It is not generally used in the borough, though it is possible with the right infrastructure and delivery systems. (CCHRC 2009).

Three CNG systems currently exist in Alaska, all providing motor fuels for transportation. The systems at Barrow and in Anchorage (the latter shown in Figure 12) both provide CNG for buses, vans, and other passenger vehicles. The system in Fairbanks, operated by FNG, is intended to provide similar commercial and retail sales in the future but currently serves only its in-house CNG fleet. No system for using CNG as a source for space heating currently exists in Alaska.

Figure 12. CNG Fueling Hose, with Storage Tanks, Anchorage, Ditch Witch.

Source: Northern Economics, Ditch Witch, Anchorage.

CNG costs are approximately half of the per-gallon gasoline equivalent. A recent purchase of approximately eight gallons cost $20, or $2.50 per gallon, compared with over $4.00 per gallon for gasoline.

Vehicles using CNG often burn gasoline as well, with the two fuels switching as required; dual-fuel vehicles can use either carburetors (preferred) or injectors. A driving radius of approximately 50 miles can be achieved with one refill of CNG.

CNG has limited potential for heating structures in the low-density areas of the FNSB. It requires in-place piping and a storage facility, much like PA systems discussed in the prior section. CNG is typically stored at 2,500 pounds PSI compared to the 200 pounds PSI for propane. Costs for individual CNG tanks and storage would be significant compared to propane. At this time the team believes conversion to CNG for space heating is less likely than PA systems.

4 Business Models

The primary goal for expanding the natural gas distribution system is to reduce energy costs (space heating and electric power) for businesses and residences in the FSNB as soon as possible. Once achieved, planners anticipate the secondary goals of stimulating economic development and improving air quality will follow. The purpose of this section is to evaluate business organization options to minimize the cost of natural gas service to residences and businesses, and maximize the number of residences and businesses that are served within five years.

4.1 Business Organization Options

There are three general business organizations that could be implemented for the FNSB Natural Gas Distribution System: 1) Private Company; 2) Non-Profit or Public Entity such as Cooperative or Municipal Utility; 3) Public/State Partnership. These three organizational models are described below using the following business parameters:

- Financial Characteristics—Capacity to raise capital or assume debt sufficient for the project plan with particular emphasis on:
  - Cost of capital
  - Cost-effectiveness of raising capital
- Organizational Characteristics:
  - Level of ratepayer control in business decisions
  - Operations and management of natural gas system
  - Transparency of governance
  - Stability
- Regulatory Requirements:
  - State and local regulatory requirements
  - Income and other tax

4.1.1 Private Company

This business organization option is based on the rules and regulations of a private utility corporation operating in Alaska such as ENSTAR Natural Gas Company and/or FNG. The company could be owned by shareholders or a private equity firm, controlled by a board of directors, and directed by management staff. Generally, a utility corporation in Alaska is regulated by the state through the Regulatory Commission of Alaska (RCA). The RCA certifies the utility to provide service for a specific geographic area and can choose to regulate the tariffs and rate of return allowable to the company.

The cost of service for a regulated natural gas utility is generally determined by the reimbursement for operating costs and the rate of return on asset equity allowed by the RCA. This provides incentive for the utility company to be efficient in its operation and investment to avoid costs that could be disallowed by the RCA. All gas utilities are subject to the standards for operations and maintenance set and enforced by the U.S. Department of Transportation’s Office of Pipeline Safety.

Generally, the State of Alaska cannot extend tax exempt bonds or grants to a private company. Presently, the only options for a private company to gain tax-exempt funding in Alaska for a natural gas distribution system would be through the use of Alaska Railroad bonds and the recent House Bill 289 (LNG Storage Facility Incentive Bill).

Recent developments in bond markets, including a drop by Moody's on the rating of Alaska Railroad bonds because of potential federal funding cuts to the railroad, make it unlikely that a private company could gain tax-exempt funding in the near term.

Other considerations related to the cost-of-service for a private company include the requirement for profit and return on investment. Private companies are subject to property and income taxes. Permitting requirements for a private company such as obtaining ROWs and environmental clearance would be similar to the other business organization options. However, a private company might be required to complete more due diligence and risk mitigation related to schedule and construction permits in order to gain the necessary financing from banks.

4.1.2 Non-Profit Organization

4.1.2.1 Municipal Utility or Cooperative

This business organization is a way to organize potential ratepayers or "the public" to participate in providing an essential service. These non-profit organizations are eligible to receive tax-exempt funding from the state and federal governments.

In Alaska, most electric power is provided by public power associations or cooperatives such as GVEA. GVEA and other electric associations were organized through federal legislation that supported electrification projects in the rural U.S. There is no equivalent federal program for natural gas utilities, and there are only a few natural gas utility cooperatives in the U.S.

In a cooperative organization, ratepayers are members that invest in the utility system and can share in the return on that investment based on their consumption. The organization is controlled by a board of directors elected by the members. A utility cooperative is regulated to serve by the RCA and is not tax exempt, but pays income taxes on a different basis than private companies.

In a municipal utility, a local government provides electric or natural gas utility service along with other government services. Anchorage Municipal Light and Power is an example of a municipal utility in Alaska. A municipal utility in Alaska is also regulated by the RCA, whose regulations can include service area definition, tariff rules and regulations, service quality criteria, and establishment of recurring rates and charges.

As a government agency, a municipal utility is exempt from income and other property taxes. There can be additional funding options available to a municipal utility as it has the authority to create bonds for infrastructure projects. This authority is limited by taxpayer approval and the bonding capacity of the municipality. Regulatory risk and permitting requirements would be the same or lower than for a private company as a municipal utility might be able to coordinate permissions and ROWs within the government agency more easily than those organizations outside the government.

4.1.2.2 Local Improvement District

Another option for a municipal or borough government is to create a Local Improvement District (LID). A LID is usually created for the purpose of acquiring, installing or constructing capital improvements, all or a portion of the costs of which may be paid by assessments against the property benefited. LIDs may be initiated either by a petition of benefiting property owners or by a local government. LIDs have been used in the Matanuska-Susitna Borough to pave roads and finance natural gas main lines and in Anchorage to construct water and sewer lines. Some of the specifics of a LID being used to finance construction of a natural gas distribution are outlined below based on recent natural gas LIDs implemented in the Matanuska-Susitna Borough.

From the gas utility perspective, LIDs are like any other main line extension project, with two notable exceptions:

1. The borough, rather than the individual property owner is the customer. The gas utility collects the main extension deposit from the borough and makes refunds of the deposit/Free Main Allowance (FMA) to the borough (over a 10-year period). The borough, in turn, pays off special assessment debt related to the project and makes refunds to the property owners.
2. The borough pays the main extension deposit after the project is complete rather than before construction begins. The borough must remit the deposit following construction so the special assessment requirements are met.

From the customers' perspective, a LID has two key advantages over a traditional utility line extension program:

1. A LID allows a property owner to finance the extension of a natural gas main line over a 10-year period, rather than remitting the full cost up front. The borough sells special assessment bonds and pays them off over 10 years, as participants pay off their assessments and the gas utility refunds the FMAs. Property owners are charged interest at prime plus approximately 1.5 percent (the interest percentage is bid each year among local banks)—historically a much better rate than most individuals can negotiate on their own.
2. A LID also spreads the cost of the project to all "benefiting properties"—even those without improvements. In a direct main extension, only property owners willing to participate provide financing for the cost of a main line extension. In a LID, all properties that benefit, even vacant lots, pay an equal share of the cost/assessment (a benefit includes an increase in property value), thus lowering the overall cost to the other participants.

The LID model can also be used to assist customers in financing the cost of heating system conversion. A form of the LID model has been used by counties in Colorado to create "special districts" that are used to finance renewable energy systems on homes.

4.1.3 Public–State Partnership

There is a spectrum of options for partnership arrangements with the State of Alaska depending how the state invests in the distribution system and the level of ownership the state retains after it is built. Some of the options include:

- Direct appropriation—the state funds the distribution system through legislation. The agreement between the agency that would own or operate the distribution system and the state would be determined in the legislation. This option would allow the state to invest in the state's infrastructure and reap the benefits of economic development associated with that investment.
- The state uses its bonding authority to obtain a lower interest rate for the utility owner for financing of system. The bonding options include:
  - General Obligation Bonds

- Bonding by a state authority such as Alaska Gas Distribution Corporation, Alaska Housing Finance Corporation, or the Alaska Railroad Corporation that has more bonding capacity than the City of Fairbanks or the boroughs and could allow access to tax-exempt bonds.
- Loan guarantee—state provides loan guarantee for the owner operator to reduce payment risk and cost of capital for the investment.

- The state acts as an investor in the project and retains some ownership to gain return on its investment. Agencies such as Alaska Industrial Development and Export Authority (AIDEA) can retain ownership in infrastructure projects with favorable terms for repayment. These agencies can also offer technical assistance such as joining the Board of Directors to ensure that the infrastructure investment is operated and maintained to protect the state's investment.

To better define the state partnership options that would be feasible for the FNSB gas distribution system, the study has developed two state partnership scenarios for the FNSB:

1. State Loan Support—the state provides a loan guarantee or bonds to support a financing program by FNSB. FNSB creates a municipal utility that would own and operate the system.
2. Joint Venture between FNSB and AIDEA to finance construction of system—create a joint venture for construction of all or part of the natural gas distribution system that would be financed by AIDEA. Ownership of system would pass to FNSB and system operation would be arranged through an operating agreement with a qualified operator.

The capacity of FNSB to raise the capital necessary for the proposed natural gas distribution system depends on the capital required and the bonding capacity of the borough at the time of construction. As of FY 2011, FNSB had about $130 million in outstanding bonds. The debt service on the majority of these general obligation bonds is partially reimbursed by the State of Alaska because they fund school construction. Also, the ratio of net bonded debt to assessed value for FNSB is the lowest it has been for 10 years at 1.51 percent. Given the current debt status of FNSB, it could be a strong partner with the state with relatively low credit risk. However, it is unlikely that FNSB could independently fund the entire system. Therefore, an arrangement with the state where FNSB either pledges or directly finances a portion of the system costs ($100 million) and the state uses other bonding mechanisms such as the Bond Bank Authority or a loan guarantee to finance the rest of the system is more feasible. With the state's current bond rating, this arrangement would support the lowest cost of service.

The natural gas distribution system should be able to quality for AIDEA's Development Finance Program, which requires that a project: "prove to be economically advantageous to the state and to the general public welfare and must contribute to the economic growth of the state". This program allows AIDEA to own "development projects" as a method of financing. AIDEA can finance a project with both debt and "cash". Most AIDEA program borrowers have customarily been issued long-term, fixed-rate loans, with an average maturity of just over 20 years. Actual experience for the AIDEA portfolio is that loans are paid off substantially before they are due—averaging between six and seven years. However, AIDEA ownership comes with some strict regulatory requirements that could restrict the operation and implementation of the natural gas distribution system.

One option to reduce the regulatory requirements is to create a joint venture between AIDEA and FNSB for the construction of the natural gas distribution system and have FNSB retain ownership and operation of the system after it is completed. This arrangement has the advantage of using lower cost capital financing of the state and avoiding some of the regulatory requirements that would be involved in having AIDEA as an owner of the natural gas distribution utility.

The results of the quantitative analysis of business structures options found that the difference in cost of capital, taxes, and profits account for about six to eight percent of the overall cost to consumers. Therefore, on a cost basis alone, the difference between business models is not likely to be the determining factor driving customers to switch over to natural gas.

4.2 Regulatory Issues

The regulation of the business organization that would own and operate the natural gas distribution system is summarized in Table 1. Different aspects of the organization such as ratemaking and governance are regulated by different entities depending on the ownership structure of the organization. Regulation of a state partnership organization is the most uncertain at this time because it will depend on the regulatory requirements included the legislation creating the partnership.

Table 10. Regulatory Structure for Business Organization Options

Regulatory Aspect	Private Company	Non-Profit (Municipal/Cooperative)	State Partnership
Permission to serve	RCA Certification	RCA Certification	RCA Certification
Consumer Protection	RCA representation	Board of Directors RCA representation	State agency and/or RCA representation
Ratemaking	RCA has the option to regulate rates.	RCA has the option to regulate rates.	Legislative or agency oversight. Structure of regulation and requirements are uncertain.
Operations and Maintenance	Federal Office of Pipeline Safety standards and oversight.	Federal Office of Pipeline Safety standards and oversight.	Federal Office of Pipeline Safety standards and oversight.
Taxes	Subject to income and property tax.	Municipal—tax-exempt. Cooperative—not tax-exempt but pays income taxes on a different basis than private companies.	Tax-exempt.
ROW permission and permitting	Must obtain permission for ROWs from landowner and land-use plan.	Municipal utility model could have lower effort for ROW and land use plan changes.	Municipal utility model could have lower effort for ROW and land use plan changes.

Source: Alaska Energy Board

5 SWOT Analysis

A SWOT analysis for each of the four business organizations discussed above (Private Company, Municipal Utility or Cooperative, Local Improvement District, and State Partnership) is included in Table 11 through Table 14. The SWOT analysis is based on the ability of the organization to meet the primary goal of achieving the lowest cost energy to the most residences and business in the Fairbanks area as soon as possible.

Some of the specific aspects considered in the SWOT analysis based on preliminary system design and costs estimates include:

- Meeting a capital investment requirement in the range of $283 million to $606 million to complete high and medium-demand areas, with a median investment requirement of about $404 million.
- Complete build-out of system within 5 years.
- Likelihood that air quality goals will be achieved. One of the keys to achieving $PM_{2.5}$ attainment is switching solid fuel (coal/wood) heating systems to natural gas. This will probably require a cost of service for natural gas near $15 per MMBtu (the cost of wood fuel for heating).

The SWOT and cost of service analysis indicate that a state partnership organization, especially with the support of grants or loan guarantee arrangements, could substantially improve project returns and end-user affordability. This business organization is the most likely to result in end-user costs near the $15 MMBtu target to promote solid fuel switching. With the monetary backing and financial support of the state, the state partnership is also most likely to achieve the trifold community goals of lowest costs, broadest service area, within five years or less.

Table 11. SWOT Analysis: Private Company

STRENGTHS	OPPORTUNITIES
• Ability to raise capital needed for initial distribution system investment and future expansion. • Can use debt or equity to raise capital. • Cost of capital depends on size and strength of corporation. • Highest internal incentive to have efficient system operations and reliability to maximize return on distribution system investment. Supports investment in in-house technical expertise for system operation and maintenance.	• New utility company in Fairbanks would strengthen local business infrastructure, create local jobs, and provide opportunities for outside investment in local community. • Potential for sales tax income to borough generated by private company gas sales.
WEAKNESSES	**THREATS**
• Highest cost of service option because corporation requires profit and return on distribution system investment. • Lowest level of transparency and ratepayer control in decision-making. • Lowest level of economic development depending on where corporate profits and investment return reside. • Subject to income and property tax.	• Little incentive to include low-density market or reduce natural gas cost of service any lower than cost of diesel fuel. If cost of natural gas service does not induce switching from wood heating, $PM_{2.5}$ attainment is less likely. • Stability and future of corporation as well as return on distribution system investment depends on the success of the management team.

Table 12. SWOT Analysis: Municipal Utility or Cooperative

STRENGTHS	OPPORTUNITIES
• Potential for lowest cost of service because: o Qualifies for state grant funding or loan guarantee to reduce cost of capital. o No profit requirements. o No income or property tax requirements for municipal utility.	• Qualifies for funding partnership with the state as grant or loan guarantee. • With lowest cost of service—highest potential for solid fuel switching and air quality attainment. • Business organization with the highest potential for ratepayer control and participation especially for cooperative model where ratepayers are owners.
WEAKNESSES	**THREATS**
• Individual cooperative or municipality/borough may not have the bonding capacity necessary to construct the system. • Lack of technical expertise in the cooperative or government organization may limit the operating or construction arrangements possible.	• Potentially weakest leadership and management structure especially with ratepayer board members. Could weaken the stability of the organization. • Potentially least flexible of the business organizations because of the board approval and regulatory requirements for raising capital or making decisions. May make future expansion of the system more difficult.

Table 13. SWOT Analysis: Local Improvement District

STRENGTHS	OPPORTUNITIES
• Use of the borough's special assessment bonding capability allows property owners to acquire access to natural gas without depleting savings or assuming the liability of a high interest home improvement loan (if the homeowner could qualify). • Have been used in Matanuska-Susitna Borough, Anchorage and other Alaska municipalities.	• The borough can benefit through increased property values and associated property taxes. • The borough can benefit from taxes on gas utility facilities. For example, the gas utility has been one of the Matanuska-Susitna Borough's largest taxpayers.
WEAKNESSES	**THREATS**
• Petition process and special assessment requirements may limit the implementation of LIDs in a region. • The borough assumes risk of repayment for construction of natural gas system. • LIDs are best implemented when city gate natural gas prices are low; likely below the prices that are feasible for Fairbanks. • New restrictions have been imposed on LIDs in Alaska.	• If property values decline or homeowners are unable to make special assessment payments, borough could have difficulty repaying special assessment bonds or experience decrease in bond rating for borough and increase cost of capital for other borough projects.

Table 14. SWOT Analysis: State Partnership

STRENGTHS	OPPORTUNITIES
• Lowest cost of capital and highest investment capacity with backing of State of Alaska • Lowest cost of service.	• Leverage state investment to achieve economic development and energy independence goals for state and borough. • Access to technical support and experience from state agencies such as AIDEA. Can participate as board members. • Potential access to state royalty gas in-kind.
WEAKNESSES	**THREATS**
• Regulatory requirements could limit state participation to construction. A limited joint venture formed between the state and the borough for the construction of the system would reduce regulatory risk associated with operating and maintaining the system. • Complicated ownership structure would reduce management and expansion options. May have to gain approval by board of directors, state regulators, and others for significant management decisions. • Highest level of oversight and bureaucracy of all of the business model options.	• Uncertain regulatory requirements depending on the structure of the partnership and oversight required by legislature.

6 Cost of Service, Financial Analysis

Prior report sections provide information on market quantities and prices (historical and current), while capital cost estimates bracketed lower and upper estimates about the likely costs of engineering, permitting, and construction of the pipe distribution system.

This section provides both information on cost of service, and financial analysis of a hypothetical organization established to operate and sell natural gas in the FNSB. Cost of service is the first major topic, followed by financial analysis, including pro forma (projected) financial statements (i.e., balance sheet and income statement).

Project analysts and economists developed an electronic spreadsheet model to illustrate and analyze how market demand and cost estimates could be used to estimate cost of service. A key factor, recognizing the uncertainty of certain assumptions and cost estimates, is a sensitivity analysis conducted on selected model components, discussed further in section 6.3.

6.1 Cost of Service

The Federal Energy Regulatory Commission (FERC) addresses pipelines that transport gas between states, but FERC definitions and concepts guide intra-state gas lines as well, including financial statements submitted by Alaska utilities to in-state regulators.

Cost of service (COS) estimates use guidelines from FERC for calculations. However, within Alaska, the Regulatory Commission of Alaska (RCA) issues certificates and requirements for public utilities; including two natural gas utilities. The RCA does not issue guidelines for calculating the COS for natural gas utilities (3AAC52.010), though it does publish regulations for electric power COS calculations (3AAC48.500), as well as tariffs for natural gas service.

The basic approach adopted by FERC is that pipeline rates should be based upon on the cost of providing service, noting "…just and reasonable rates require a balancing of equities between the interests of the pipeline and its ratepayers" (FERC, 1999).

The RCA provides oversight of in-state gas lines, including the system proposed in Section 3 of this report. In general, the RCA uses the same financial information to analyze costs of service to consumers, both public and private, residential and commercial. The initial figures are called the *rate base*, which is defined as:

Gross plant (or capital costs of pipelines, plus compressors, etc.)
- Accumulated depreciation (if any)
= Net plant
- Accumulated deferred income taxes (if any)
+ Working capital
= Rate base.

Cost of service consists of the rate base, defined above, times the overall rate of return, plus the items listed below, minus revenue credits:

= Return
\+ Operation and maintenance expenses
\+ Administrative and general expenses
\+ Depreciation expense
\+ Non-income taxes
\+ Income taxes
\- Revenue credits
= Total Cost of Service

Note that conversion costs from fuel oil to natural gas for individual residences and commercial entities are not included in this formula, but they are addressed in other sections of this report.

After market demand and conversion costs were finalized, team members developed a spreadsheet model to project potential (pro forma) costs of service and projected financial performance.

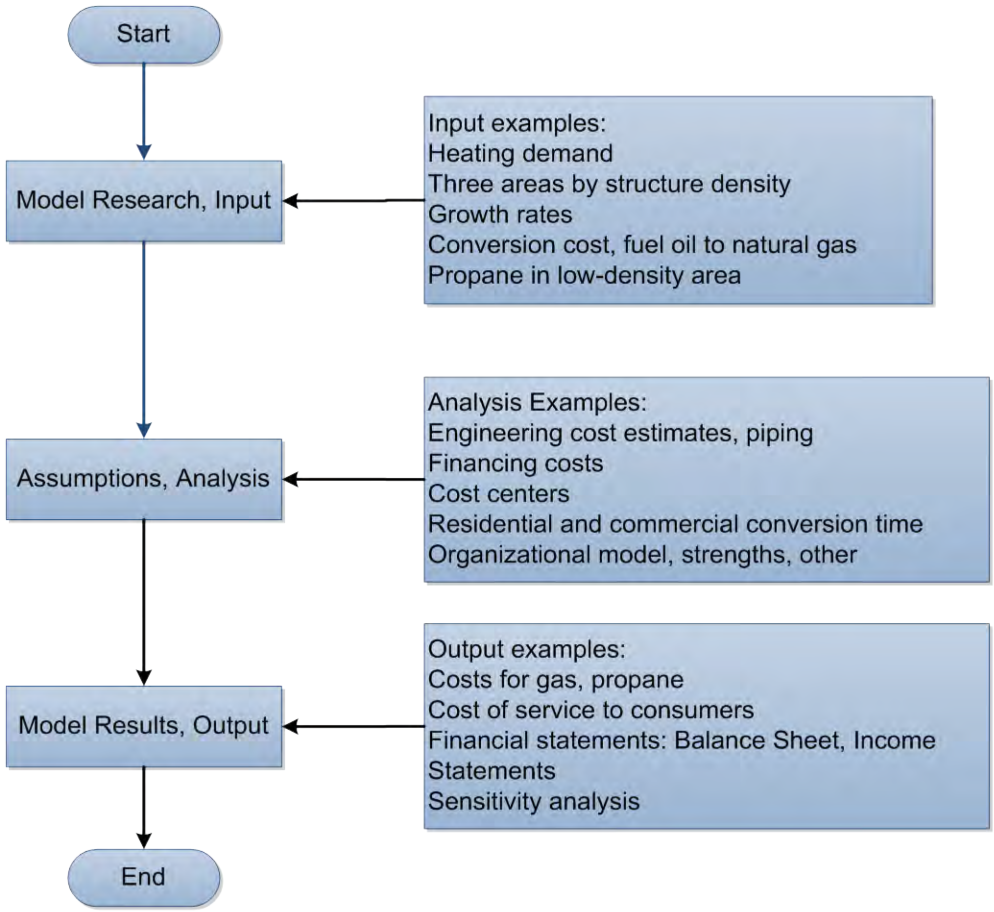
This section provides information about the model, certain key assumptions, conversion costs, and output, including estimated cost of service and basic financial statements.

6.2 Base Model, Cost of Service, Financial Analysis

Team analysts selected a spreadsheet model to 1) provide flexibility in modeling, 2) enable export of data to the sensitivity analysis software, and, perhaps most important, 3) provide transparency as to the variables and data used. An electronic version of the model accompanies final submittal of this report to the client project managers. Key model assumptions, analysis, and output are discussed in the next several sections.

Figure 13 illustrates three basic model sections (input, analysis, and output) and some of the key variables that are included (or generated) in each.

Figure 13. General Flowchart of Cost of Service and Financial Analysis



Source: Northern Economics, Inc.

6.2.1 Model Inputs

Key model variables include demand, both within and outside of the piped distribution area, as well as growth and conversion rates. These items are discussed in the following sub-sections.

Number of Residential and Commercial Structures

FNSB GIS databases formed the basis for estimates of the number of residential and commercial structures. The piped distribution area contains an estimated 20,863 residential structures and 1,794 commercial structures after adjustments are made to subtract the homes, businesses and non-private buildings (schools, government office) that are currently heated by FNG and Aurora Energy, LLC. Of these structures approximately 80.4 percent use distillates for heating with the balance of 19.6 percent heating with wood and other sources.

Over the 50-year period included in the gas model (the financial model is 20 years, reflecting loan terms), the average annual growth is 1.004 percent as derived from analysis of the FNSB Assessor's Database and the growth in housing stock from the earliest known building (1902) to those built in 2011.

For sensitivity purposes, the lower and upper annual average growth rates are 0.41 percent and 1.6 percent, respectively.

Annual Consumption per Structure

Heating consumption per year by type of structure (residential, commercial) is based on experienced heat requirements for similar buildings in Anchorage, and adjusted to Fairbanks using heating degree days. Team engineers and analysts compared the estimated results to actual heat requirements for specific buildings as noted by Aurora Energy LLC in a 2009 presentation. There are differences between estimates and actual amounts for each structure of about plus or minus five to ten percent but the differences tend to offset each other with the sum of the differences being relatively minor.

Fuel Efficiencies

Table 15 summarizes fuels available within the FNSB, and their characteristics. As noted below, natural gas and propane boilers or furnaces are estimated to have an average efficiency of 90 percent and a lower range of 85 percent and an upper range of 95 percent, representing furnace and boiler efficiencies reported by contractors and suppliers, both in Fairbanks and Anchorage. Oil-fired boilers and furnaces are assumed to have efficiencies of approximately 85 percent, and wood-fired units are estimated at 68 percent efficiency.

Table 15. Fuel Types, Price, Heat, Efficiency, and Ranking by Heat Cost

Fuel	Average Price ($)	Units	Gross Heat (Btu)	Efficiency (%)	Mid-point (%)	$/100,000 BTU	Useful BTU/$1	Rank
Electricity	0.1976	kWh	3,413	95 - 100	98	5.938	16,840	11
District Hot Water	27.0300	MMBtu	1,000,000	95 - 100	98	2.772	36,071	7
District Steam	10.5000	MMBtu	1,000,000	95 - 100	98	1.077	92,857	1
Fuel oil (#2)	4.0500	gallon	135,000	80 - 90	85	3.529	28,333	8
Current natural gas	23.3500	Mcf	1,000,000	85 - 95	90	2.594	38,544	5
Propane, small vol.	4.3500	gallon	91,333	80 - 90	85	5.603	17,847	10
Propane, heating	3.0500	gallon	91,333	85 - 95	90	3.710	26,951	9
Wood, pellets	295.000	ton	16,000,000	68	68	2.711	36,881	6
Wood, birch	250.000	cord	20,500,000	68	68	1.793	55,760	3
Wood, spruce	250.000	cord	15,000,000	68	68	2.451	40,800	4
Coal, stoker	110.000	ton	15,200,000	55	55	1.316	76,000	2

Source: Northern Economics

Note: Efficiency is based on Annual Fuel Utilization Efficiency (AFUE) or estimates from the Cold Climate Housing Research Center or federal EPA (primarily wood).

Rankings shown in the last (rightmost) column reflect BTU per $1 spent on energy, from the highest ranking (district steam) to the lowest ranking (electricity).

Energy Required

Energy required for structures in the piped distribution areas is calculated for residential and commercial structures by high and medium density areas, and then summed. In 2021 residential demand is estimated at about 5.5 Bcf and commercial demand is estimated at approximately 4.7 Bcf.

Industrial demand includes demand from the PetroStar refinery which is estimated at 0.3 Bcf per year.

Residential, Commercial Conversion Costs

Table 16 shows three sets of cost estimates for residential conversion to gas. The estimates vary considerably, depending on the extent of the conversion. At the low end, FNG (2005) gives a conversion cost of $1,000–$1,500 to replace an oil-fired gun with a gas-fired gun. At the high end, Laabs (2012) provided cost estimates for a complete replacement, reaching upwards of $12,000–$20,000 for a boiler replacement, chimney upgrade (or replacement) and other hydronic (or forced air) connections.

Table 16. Cost Estimates for Residential Conversion to Natural Gas

Source	Notes	Cost Estimate ($)
Fuhs (2010)	Space heater with flush mount exhaust, on-demand hot water heater, and 250 gallon buried tanks—to be refilled about once per month, depending on season	3,000
Fairbanks Natural Gas (2005)	Replacement of gun, residential	1,000–1,500
Laabs (2012)	Furnace replacement, mobile home	6,000–8,000
	Chimney replacement (if needed), mobile home	500–700
	Furnace replacement, residential	8,000–15,000
	Chimney replacement (if needed), residential	2,500–5,000
	Boiler replacement or conversion from oil to gas, residential	12,000–20,000
	Burner conversion with boiler brushed out, residential	3,500–6,500

Source: Northern Economics, Inc. from sources noted.

The cost for converting commercial systems is specific to the structure that is being converted and sources could not provide a reliable number of commercial structures. For modeling purposes, the average per square foot cost of converting a residential structure was applied to the average size of commercial buildings as determined from the Assessor's data base.

Natural Gas Sales in High and Medium Density Areas

Total natural gas sales (market demand) for residential, commercial, and industrial consumers in the piped distribution area in 2021 is estimated at approximately 10.8 Bcf (See Table 6). Conversion rates for residential structures transitioning from other fuels to natural gas in the high density zone are expected to occur over five years at the following rates:

- 10 percent
- 25 percent
- 25 percent
- 25 percent
- 12 percent

If the delivered price of natural gas plus conversion costs is less than or equal to 90 percent of the fuel oil price 97 percent of the residential structures are anticipated to switch to gas and 100 percent of commercial users. Similar percentages apply to conversions from wood heat if the gas price plus conversions costs is less than or equal to 110 percent of the wood cost.

Commercial conversion rates are estimated to occur over four years at the following rates:

- 15 percent
- 35 percent
- 35 percent
- 15 percent

The medium density zone has the same conversions rates but conversions do not begin until 2016, which is the first year that natural gas is expected to flow in this area.

Low-Density Area

Team analysts applied similar energy analysis for consumers (residential and commercial) in the low-density areas, using propane instead of natural gas. Total propane sales for residential and commercial consumers in 2021 is estimated at approximately 0.8 Bcf.

The most likely scenario includes external propane tanks, 250 gallons of capacity or greater, traditional truck delivery of propane, and propane sourced from the Alaska North Slope or another location with propane prices lower than current sources.

If the delivered price of propane plus conversion costs is less than or equal to 90 percent of the fuel oil price 95 percent of the residential structures in the low density area are anticipated to switch to propane and 100 percent of commercial users. Similar percentages apply to conversions from wood heat if the propane price plus conversion costs is less than or equal to 110 percent of the wood cost.

Total Natural Gas and Propane Sales in FNSB

The model provides estimates of total natural gas required by residential, commercial, and industrial segments for the two zones that are piped for distribution. For the low-density zone, estimates suggest how much residential and commercial segments switch to propane. All estimates are expressed by year from Year 1 (2015) to Year 50 (2065). Total sales of natural gas and propane within the FNSB are projected at approximately 11.4 Bcf in 2021 and increasing slightly more than 0.1 Bcf per year.

Natural Gas Price

The price of natural gas at the Fairbanks city gate is assumed to approximate $10 per MMBtu in 2015. A portion of that price is the cost to purchase the gas and the remainder is other costs that would be incurred to move the gas from its source to the city gate.

Operations and maintenance costs

Operations and maintenance costs were drawn from financial statements of FNG and ENSTAR, as reported to the RCA. The model uses a linear interpolation of operations and maintenance costs based on gas volumes for FNG and ENSTAR. This results in a cost per MMBtu that changes with the general inflation rate and total gas volumes handled. In 2015, this cost is approximately $0.49 per MMBtu.

Administrative and general overhead

These are based on public figures for FNG and ENSTAR, as reported to the RCA. The model uses a linear interpolation of administrative and general overhead costs based on gas volumes for FNG and ENSTAR. This results in a cost per MMBtu that changes with the general inflation rate and total gas volumes handled. In 2015, this cost is approximately $2.55 per MMBtu.

Depreciation, Distribution System

Depreciation expenses are based on the mid-case engineering estimate of $404 million to develop the piped distribution systems. Depreciation expenses are expressed on a per-MMBtu basis using total natural gas sales for the piped area, as projected each year for 20 years (to 2035).

Capital costs

Capital costs are those prepared by team engineers and included and discussed in Section 3.0 of this report. Lower case costs are estimated at $283 million and upper case costs are $606 million.

Grants

Certain types of business models, such as government-owned utilities, or cooperatives, qualify to receive grants funds from local, state, or federal governments; private utilities do not qualify. The mid-case estimates of grants for government-owned utilities or cooperatives is 50 percent with a range of zero to 70 percent. If grants are not available then the cost of service becomes closer to, but still less than that of a private firm.

Business Structure

This model feature is a toggle that essentially flags the analysis as private or other, with private firms not qualifying for grants, and incurring higher interest rates (for loans) and also paying taxes, something public organizations avoid.

Debt Service

This part of the model uses the net amount of capital costs, less grants (if any), as a loan amount, with interest rates of 6.0 percent for private firms and 4.5 percent for others. Loans are assumed to extend for 20 years, the number of years covered by the financial analysis.

Aggregate amounts per year for debt service are summed and expressed as a cost per MMBtu.

General Inflation Rate

A general inflation rate of 2.5 percent is used for those cost items that do not have specific inflation factors.

Taxes

The combined federal and state corporate income tax rate is 40.2 percent. However, the effective corporate income tax rate is often lower than this combined rate due to various tax credits and other factors that can reduce the tax liability. However, private entities would incur property taxes which, when considered with the lower effective tax rate, suggest that the overall (income and non-income) tax rate would be in the vicinity of 40.2 percent.

Profit or Retained Earnings

Profit represents the amount of cash left over for a firm once operating expenses and the cost of debt are subtracted from revenues. Retained earnings represent the equity or excess asset value after subtracting out liabilities. For a private firm, starting equity would be the amount of cash invested in the distribution system. For a public firm, grant funding would be used to establish retained earnings. The model assumes all profits are reinvested in the firm, resulting in retained earnings that increase over time. Alternatively, a firm could choose to distribute retained earnings in the form of dividends and returns of capital (for a private firm), distribution of earnings to members (for a cooperative), or through transfers to other funds (for a government entity).

6.2.2 Model Outputs

Model outputs include total estimated demand and sales, for both the piped and low-density areas, along with projected costs of service, debt (loan) service, and pro forma financial statements. More specific information is noted below.

Cost of Service for Natural Gas Pipeline Distribution System

The cost of service represents the price to the consumer. This estimate assumes the same rate for all users whether they are in a high density area or a low density area, and whether the user is a residential, commercial, or industrial entity. Estimated costs and selling value per MMBtu are shown in Table 17 for a private organization and Table 18 for a public (or cooperative) organization.

Table 17. Pro Forma Cost of Service for Natural Gas Distribution System Private Organization, in $/MMBtu

Piped Distribution Area Gas Price (Medium, High)	2015	2016	2017	2018	2019	2020
Natural gas price ($/MMBtu), well head	3.51	3.52	3.63	3.72	3.82	3.91
Other cost ($/MMBtu), growth rate	6.49	6.51	6.72	6.89	7.06	7.23
Operations & maintenance cost ($/MMBtu), base rate	0.49	0.50	0.51	0.53	0.54	0.55
Admin & General Overhead, base rate	2.50	2.55	2.60	2.66	2.72	2.78
Depreciation, distribution system, total and $/MMBtu	6.78	2.20	1.21	0.90	0.80	0.77
Subtotal	19.77	15.28	14.68	14.70	14.94	15.25
Debt service and return on equity, $/MMBtu, piped system	0.79	3.13	3.10	3.07	3.04	3.01
Total cost per MMBtu	20.56	18.41	17.77	17.77	17.97	18.26
Total selling value with 20% margin over cost	24.67	22.09	21.33	21.32	21.57	21.91

Source: Northern Economics

Table 18. Pro Forma Cost of Service, Piped, Public Organization, in $/MMBtu

Piped Distribution Area Gas Price (Medium, High)	2015	2016	2017	2018	2019	2020
Natural gas price ($/MMBtu), ANS, well head	3.51	3.52	3.63	3.72	3.82	3.91
Other cost ($/MMBtu), growth rate	6.49	6.51	6.72	6.89	7.06	7.23
Operations & maintenance cost ($/MMBtu), base rate	0.49	0.50	0.51	0.53	0.54	0.55
Admin & General Overhead, base rate	2.50	2.55	2.60	2.66	2.72	2.78
Depreciation, distribution system, total and $/MMBtu	6.78	2.20	1.21	0.90	0.80	0.77
Subtotal	19.77	15.28	14.68	14.70	14.94	15.25
Debt service, $/MMBtu, piped system	0.35	1.39	1.38	1.37	1.35	1.34
Total cost per MMBtu	20.12	16.67	16.06	16.07	16.29	16.59
Total selling value with 10% margin over cost	22.13	18.34	17.66	17.68	17.92	18.25

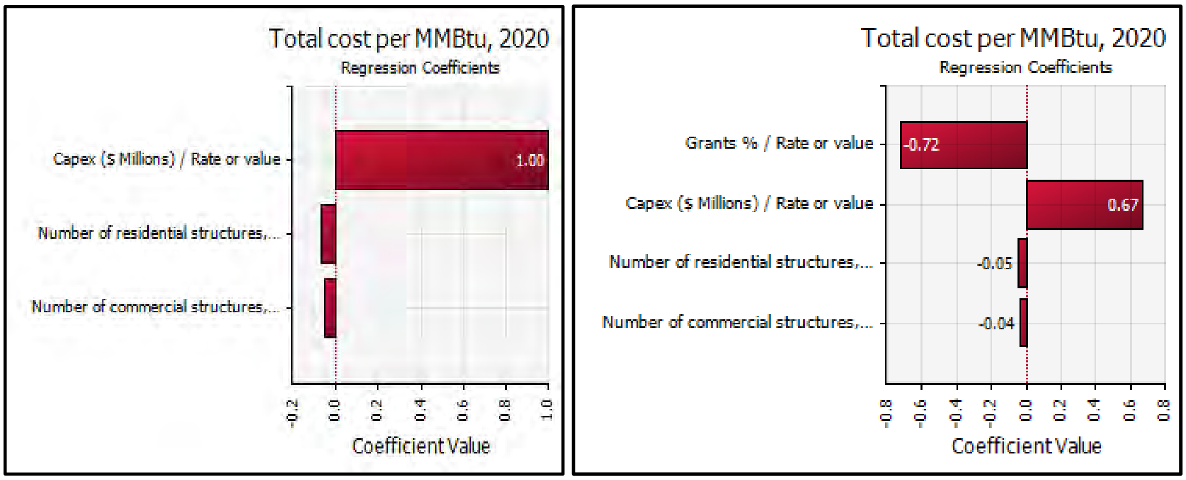
Source: Northern Economics

As shown above, the cost of service for a private organization is higher than the cost of service for a public organization. This is generally due to the higher costs incurred by private entities for financing and taxes.

6.3 Cost of Service Sensitivity Analysis

The total cost per MMBtu of delivered gas is most sensitive to the distribution system's capital cost and grant funds received (only for a government-run or cooperative utility). Figure 14 shows a tornado diagram for the year 2020 highlighting the relative importance of these factors. The growth rates for the number of residential and commercial structures have a small initial effect, but their importance increases over time.

Figure 14. Cost of Service Tornado Diagram, 2020

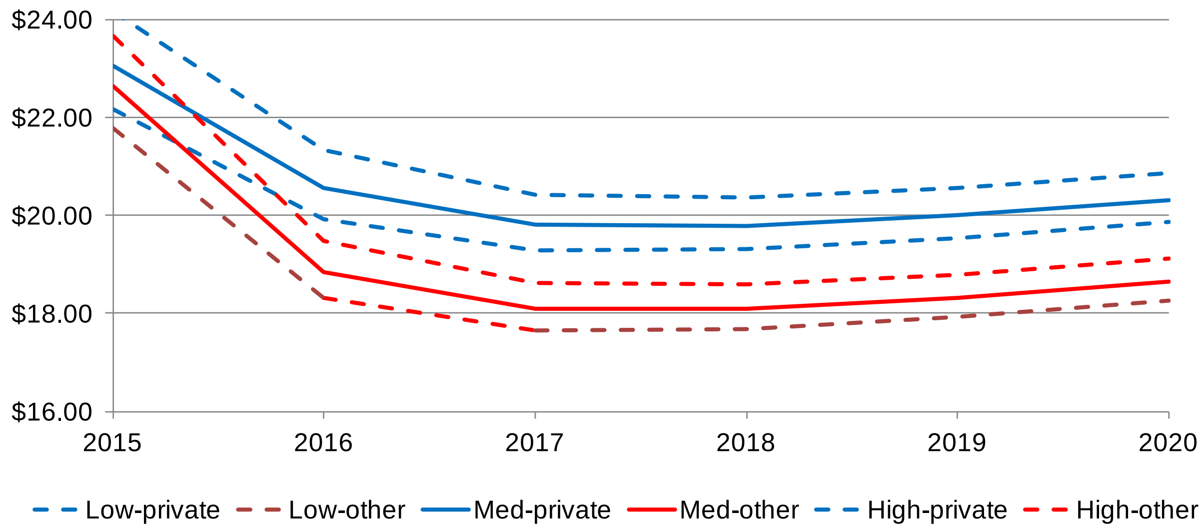


Private **Public/Other**

Source: Northern Economics, Inc.

Figure 15 shows cost of service estimates from 2015 through 2020 for private and non-private (other) entities. The results shown here are taken from the sensitivity analysis and represent various probabilities for the outcomes. The cost of service lines shown in the chart do not match with the cost of service discussed in the preceding tables because the sensitivity analysis is based on a simulation rather than a static model. The declining cost of service is a result of the gradual conversion over time; as residential and commercial structures convert to natural gas, the total cost of service drops. The low estimates represent the probability that the costs of service will be at or below this price for 25 percent of the model runs. The medium estimate (Med) anticipates that the cost of service will be at or below this price for 50 percent of the model runs, and the high estimate anticipates that the cost of service will be below this price for 75 percent of the model runs. As noted earlier, some of the reasons why the private entity has a higher cost structure include taxes, higher financing costs, and the availability of grants for the public entities and cooperatives.

Figure 15. Cost of Service Estimates with Margin, Low, Medium, High, by Organization, 2015 to 2020.



Source: Northern Economics, Inc.

The cost of service for propane consumers in the low-density area of the FSNB is estimated at approximately $24 per MMBtu in 2015, assuming that lower priced propane is available from the North Slope or elsewhere in the state. A propane distributor that was owned and operated by a public entity or cooperative would have many of the same advantages as a public or cooperative pipeline distribution system entity. Figure 15 indicates that after the initial years, the cost advantage for a public entity is about nine percent. Applying this same percentage to the cost of service for a private propane distributor suggests that a public entity might have a delivered cost of about $21.80 per MMBtu.

6.4 Pro Forma Financial Statements

Financial statements serve as metrics for management primarily, but they also serve others, such as lenders (banks), owners (stock holders), and regulators (RCA).

Many rules and formulas govern how financial statements are prepared, from the Generally Accepted Accounting Principles published by the Financial Accounting Standards Board or those prepared for government entities published by the Government Accounting Standards Board.

There are two main types of financial statements, whether prepared for a business organization or a public entity: balance sheets and income statements.

Balance sheets list an organization’s owned assets (e.g., buildings, pipelines, vehicles) at a given point in time (a snapshot) and also any liabilities incurred from owning the assets. A typical example is a pipeline or a building hypothetically purchased for $100,000 and paid for with $70,000 of loans (debt) and with $30,000 of stockholder’s funds (equity).

By contrast, income statements record revenues and expenses generated by the organization and its assets over a given period of time (much like a video, not a snapshot). Typically, balance sheets are published at the end of a fiscal year, and income statements record twelve months of revenues and expenses between published balance sheets. The well-known *bottom line* refers to the amount remaining after expenses are subtracted from revenues, also known as net income.

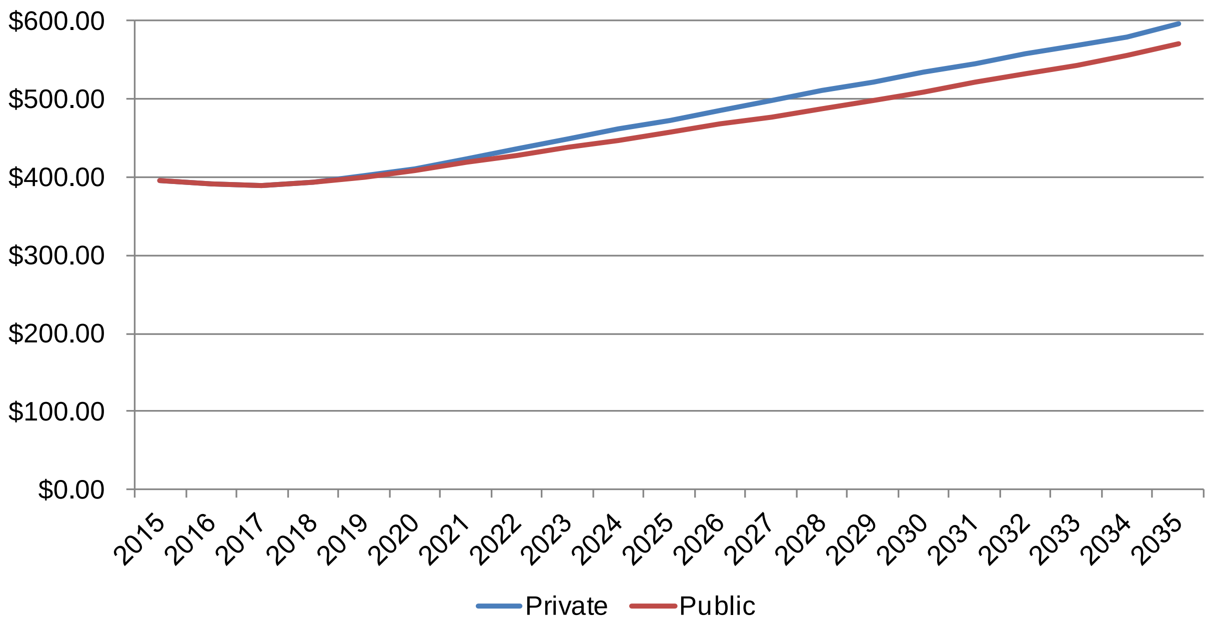
For purposes of this analysis, both balance sheet figures and the amounts estimated as revenues and expenses are forecasts (pro formas) and do not represent any actual transactions. Both statements are simplistic and consolidated to highlight key figures and potential amounts for relative comparison and evaluation.

6.4.1 Balance Sheet

Two analyses of total assets generate the differences between public and private organizations, as shown in Figure 16 below. With the same margin on natural gas sales, public corporations accumulate total assets more quickly than private firms due to lower borrowing rates, their ability to seek and apply grant funding, and their exemption from paying income taxes. The figure assumes a private firm would have a higher margin on the gas it sells to account for its higher costs.

This figure assumes that the public organization retains its earnings over time, rather than distributing its earnings to cooperative members or transferring them to other funds within a municipal or borough government. Likewise, the figure assumes a private firm would retain all earnings rather than distribute dividends to its stockholders.

Figure 16. Pro Forma Total Assets, Private vs. Public Organization, $Millions



Source: Northern Economics

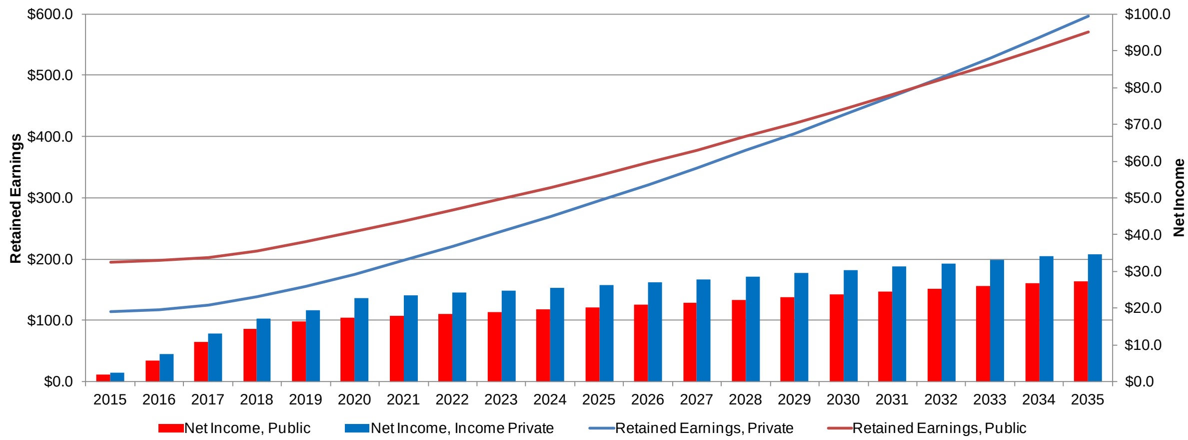
6.4.2 Income Statement

Figure 17 shows pro forma net income and retained earnings for both private and public entities. Private companies need to generate more revenue than public entities since they will typically have a higher interest rate on their debt, and private firms also incur taxes which reduce the amount that they can invest in the future.

Public firms can accept grant funding (in the model a base estimate is 50 percent) and their debt load is lower as a result. Public firms also have a higher net income since they do not pay income taxes.

The figure shows the higher net income of a public firm and the corresponding higher retained earnings, relative to a private firm, over time. In 2015, the gap in retained earnings between the two types of organizations is approximately $80 million, a situation that reverses over the following 20 years due to the private firm's higher margin, resulting in $25 million more in retained earnings for the private firm in 2035. The initial difference of $80 million reflects the 30 percent equity a private firm would invest up front versus the 50 percent grant funding with which a public firm would build the distribution system. The difference in net income is very small ($400,000) in 2015 and grows to about $7 million by 2035, reflecting the higher margin charged by a private firm, which it uses to cover the higher costs of debt and income taxes.

Figure 17. Pro Forma Net Income and Retained Earnings, Private vs. Public Organization, $Millions



Source: Northern Economics

7 Consumer Savings

The natural gas and propane alternative results in substantial savings for residents and businesses in the borough compared to the status quo. Table 19 shows the estimated annual fuel costs for the status quo and the natural gas and propane alternatives for the 2015 through 2022 time period, and the resultant cost savings.

Table 19.Fuel Costs and Savings

Alternative/ Sector	2015	2016	2017	2018	2019	2020	2021	2022	Total 2015-2021	Total 2015-2022
	(Millions of Nominal $)									
Status Quo										
Residential	219.9	223.3	234.9	245.2	255.6	266.3	277.5	289.7	1,722.7	2,012.4
Commercial	187.3	189.8	200.0	209.0	218.0	227.3	237.1	247.7	1,468.5	1,716.2
Industrial	8.0	8.0	8.3	8.6	8.9	9.2	9.5	9.8	60.6	70.4
Total	415.1	421.2	443.2	462.8	482.6	502.9	524.1	547.3	3,251.8	3,799.1
Natural Gas/Propane										
Residential	213.5	193.5	168.4	139.4	119.5	116.5	120.2	124.2	1,071.1	1,195.3
Commercial	178.4	141.9	102.1	80.4	79.4	81.7	84.1	86.8	748.1	834.9
Industrial	7.0	5.0	4.8	4.8	4.9	5.0	5.1	5.2	36.6	41.8
Total	399.0	340.4	275.3	224.7	203.8	203.2	209.5	216.2	1,855.8	2,072.0
Savings										
Residential	6.3	29.8	66.5	105.8	136.1	149.8	157.3	165.5	651.6	817.1
Commercial	8.8	47.9	97.9	128.5	138.7	145.7	152.9	160.9	720.4	881.3
Industrial	1.0	3.0	3.5	3.8	4.0	4.2	4.4	4.7	24.0	28.7
Total	16.2	80.8	167.9	238.1	278.8	299.7	314.6	331.1	1,396.0	1,727.1
Savings as a % of Status Quo	4%	19%	38%	51%	58%	60%	60%	60%	43%	45%

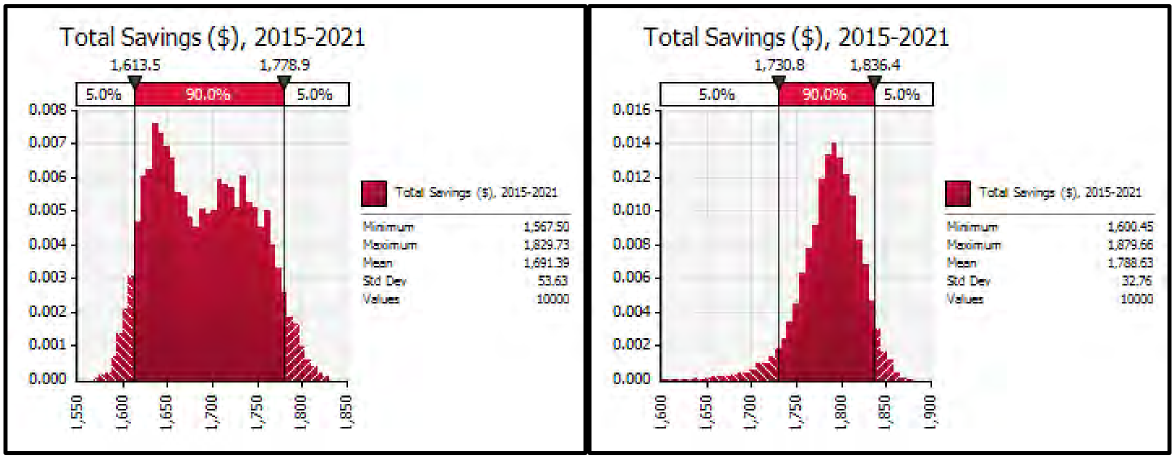
Source: Northern Economics, Inc. estimates.

In 2021, the first full year of operations, the savings are approximately $315 million or a savings from the status quo of about 60 percent. The total for the 2015 through 2021 time period is approximately $1.4 billion.

It is uncertain if or when GVEA and Flint Hills might connect to the gas distribution system, but at some point in the future if a gas pipeline is built to Fairbanks it may be more cost effective for these two firms to use the piped distribution system rather than continue to truck LNG from the North Slope. While the industrial firms could benefit from being connected to the distribution system, residential and commercial customers could benefit from the greater throughput, which reduces the fixed costs per unit.

A probability-based sensitivity analysis was conducted on consumer savings for both a private entity and a non-private entity for the 2015-2021 time period. As shown in Figure 18 the mean estimate of consumer savings is similar for each entity. The private entity has mean savings of approximately $1.69 billion and the public entity has mean savings of approximately $1.79 billion. As with the other comparisons of private and public entities, the public entity has slightly better performance than a private entity.

Figure 18. Sensitivity Analysis for Consumer Savings



Private **Public/Other**

Source: Northern Economics, Inc.

8 Benefit-Cost Analysis

In addition to a financial analysis the study team also conducted a Benefit-Cost Analysis to show the cost savings to residential, commercial, and industrial users from the conversion to natural gas from other fuels, primarily distillates or wood. Broadly defined, a BCA is an assessment of all the quantifiable benefits, minus all quantifiable costs of a project. The difference between the two is the BCA ratio, and indicates whether, overall, the project is a net positive or negative.

Benefit-Cost Methodology

BCA helps decision-makers determine if a project generates more benefits than costs; if it does, the ratio is 1.0 (or better). For example, if a pipeline costs $100,000 but it generates $150,000 of benefits over its lifetime, the ratio is 1.5 ($150,000/$100,000).

Further, since a project lifetime can extend far into the future, money has a time value: dollars in the current year are considered to have more value than dollars in the future, especially if the BCA is looking at a 50-year project lifecycle. Economists and analysts use a concept called Net Present Value (NPV) to measure benefits and costs at the same point in time, to avoid vast differences in potential cash flows. NPV calculations determine present values using an interest rate (or, more precisely, a discount rate) to bring future streams of cash values to a common (current) time.

Benefit-Cost Calculations versus Financial Analysis

A BCA differs from a financial analysis because costs are recognized in the year in which the total expenditure occurs, not the year in which the debt repayment is made. Thus, projects that require large upfront capital expenditures prior to any revenues being generated have to overcome that disadvantage compared to a project that had lower initial capital costs but potentially higher costs in the future.

A BCA also differs from a financial analysis in the numbers that are used for each method. A BCA includes the cost savings from society's point of view (i.e. before taxes and financing costs, which are mere transfers between different groups in society). These costs are relevant from the project sponsor's point of view and should be analyzed in the financial analysis since they will have an impact on whether the investor will be willing to participate in the project or not.[3]

However, in a BCA, whether the project is beneficial for society is driven by the net present value of cost savings from the project itself, and not the way the project might be financed. Otherwise, a "bad" project could look good simply by virtue of its sponsors having access to concessional funding on terms more favorable than what the financial markets offer. Conversely, a "good" project may look "bad" only because its sponsor is unable to secure more favorable loan conditions available elsewhere in the market. For this reason it is important to consider both BCA and financial analysis as complements in the decision-making process.

The BCA compares the present value of a stream of costs associated with a project compared to the present value of a stream of costs without the project. The benefit-cost ratio is calculated by dividing the net present value of the project alternative into the net present value without the project. The larger the ratio, the better the project is ranked. In practice, any project that is greater than 1.0 is deemed worthy of funding although, in the presence of budget constraints, higher ranked projects may use all of the available funds and preclude the project from being funded despite a benefit-cost ratio higher than 1.0.

[3] Different debt to equity ratio and different debt arrangements (rates of interest and/or maturities) will generate different financing costs for the project's owners.

Benefit-Cost Analysis of Fuel Conversion

The study conducted the BCA of cost savings to users from conversion to natural gas from other fuels using the mid-estimates from the financial and cost of service task (see Section 6.2.1) as inputs. The study then conducted a sensitivity analysis for the BCA ratio, the results of which are discussed in Section 8.1.2.

The BCA also addresses, in a preliminary manner, the benefits due to emissions reductions—focusing on reductions in fine particulate matter—and the benefits from reductions in other greenhouse gas emissions. Obviously, these are more difficult to calculate and require subjective analysis.

8.1.1 Natural Gas/Propane Distribution System

Table 20 presents the results of the BCA comparing the status quo (distillates and wood remain as the primary fuels for heating and industrial demand in the FNSB), and an alternative that would see natural gas available via a piped distribution system in high- and medium-density areas of the FNSB, and propane or PA available in the low-density areas of the borough. CNG was evaluated early in the analysis but was found to be more expensive than propane due to the costs for tanks capable of meeting pressures of 2,500 pounds per square inch and was dropped from further consideration.

The natural gas could come from the North Slope, Cook Inlet, or other potential discoveries in the Interior. Similarly, lower cost propane could be available from the North Slope or other potential discoveries in the state. Additional details on the assumptions and data used in this BCA are presented later in this section.

Table 20. Summary With and Without a Natural Gas/Propane Distribution System

	Billions of $		
Alternative	**Present Value of Costs**	**Present Value of Cost Savings**	**Benefit-Cost Ratio**
Status Quo	**10.62**	**--**	**--**
High Density Area	7.10	--	--
Medium Density Area	2.65	--	--
Low Density Area	0.86	--	--
With Natural Gas/Propane Alternative	**5.25**	**5.36**	**2.02**
High Density Area	3.27	3.83	2.17
Medium Density Area	1.46	1.20	1.82
Low Density Area	0.53	0.33	1.63

Source: Estimates by Northern Economics, Inc.

Note: Costs are discounted using a seven percent discount rate. Benefit-cost ratio is calculated as cost of status quo (savings or benefits) divided by the cost of the natural gas/propane alternative.

Converting to natural gas and propane provides substantial savings to borough residents and businesses, and these benefits extend over all three density zones. The highest benefit-cost ratio occurs in the high-density area, where the price for natural gas is low enough to achieve high market penetration, and where development densities result in a large number of users per mile of pipeline.

The lowest benefit-cost ratio occurs in the low-density zone, where propane is not priced low enough to provide an incentive for residences that use wood for heating to switch to propane, and where the price differential between propane and heating fuel is less than the price difference between natural gas and heating fuel.

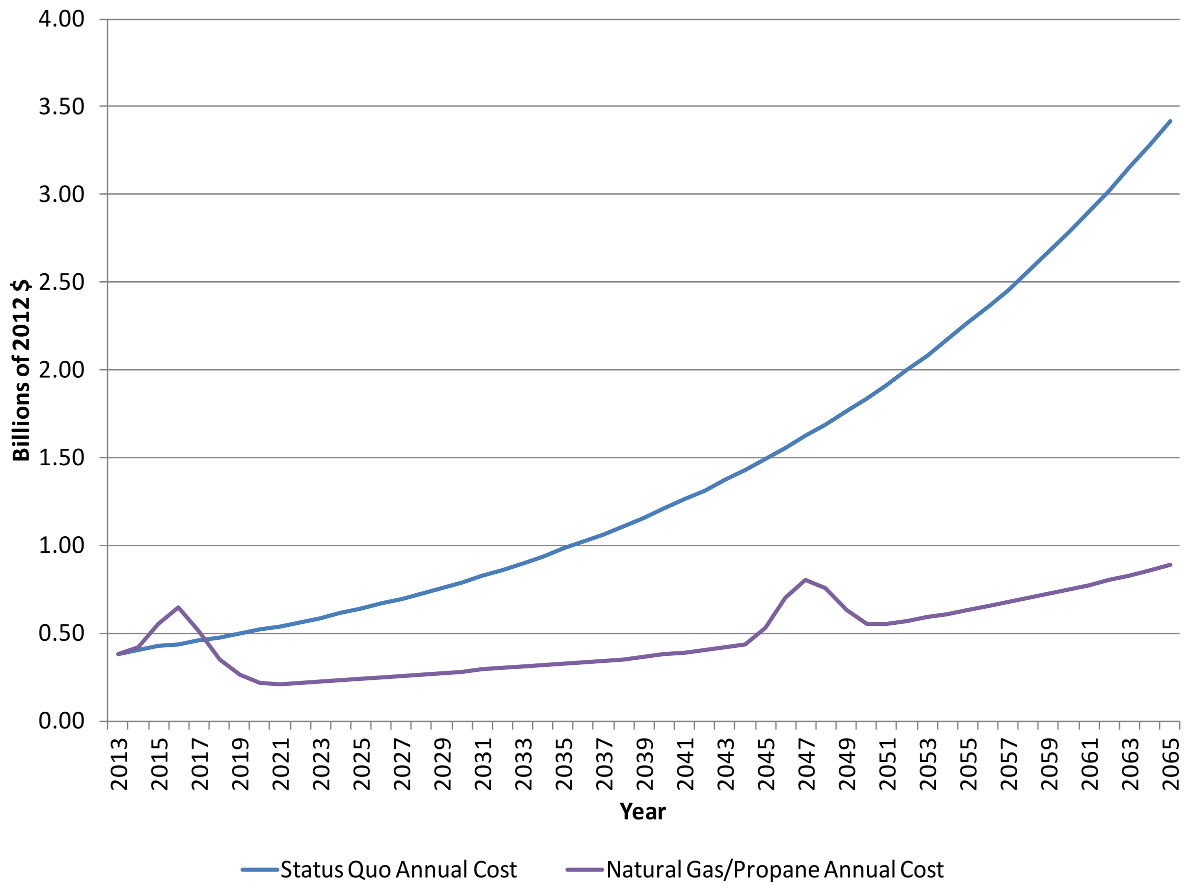
The present value of costs in the status quo for the 50-year study period through 2065 for the entire FNSB is estimated at approximately $10.62 billion in 2012 dollars. This amount includes the cost of the fuels, and replacement of existing furnaces and boilers on a 30-year schedule. Replacement of industrial facilities was not modeled because these facilities are anticipated to be replaced on the same schedule with either alternative, which means they would cancel each other out in the cost savings and benefit-cost ratio. The estimated cost disaggregated for the high, medium, and low-density areas of the borough are also presented in the table.

The present value of costs of an alternative using natural gas and propane to meet the heating and industrial demand is estimated at approximately $5.25 billion in 2012 dollars. This amount includes the cost of the fuels, conversion costs for replacing the existing furnaces or boilers, and the capital and operating costs for the piped distribution system. This estimate also includes the cost of new propane trucks and tanks to serve the low-density area of the borough; similar to the status quo, estimated costs for the high, medium, and low-density areas of the borough are presented in the table. The $5.25 billion also assumes that the distribution system is operated by a private company, which results in a more conservative comparison since government or cooperatives would be expected to have lower costs, as discussed earlier in the report (see Sections 4.1 and 7).

The net present value expressed in 2012 dollars of the potential cost savings from converting to lower cost natural gas and propane is estimated at approximately $5.36 billion over the 50-year study period.

Figure 19 presents the estimated annual costs for each alternative. These amounts are first estimated in nominal dollars assuming a 2.5 percent general inflation, and then discounted back to 2012 dollars using a 7.0 percent nominal discount rate as suggested by the federal Office of Management and Budget.

Figure 19. Estimated Annual Costs Under Status Quo and Alternative Project



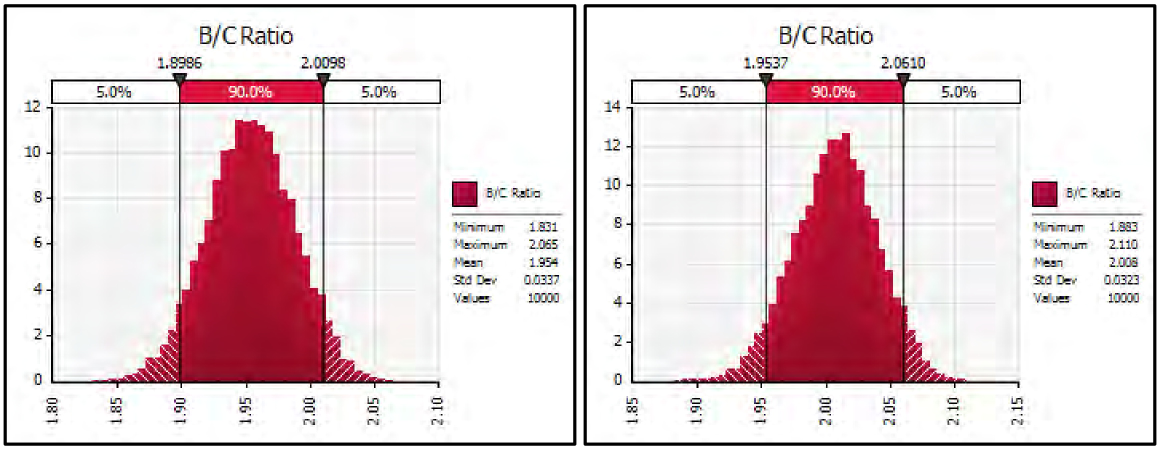
Source: Northern Economics, Inc.

The conversion alternative has higher costs in the initial years due to the capital expenditures for the piped distribution system and the propane delivery system, as well as the conversion of existing furnaces and boilers to natural gas or propane-fired units. However, once those costs are incurred, the lower fuel costs quickly result in the natural gas/propane conversion alternative being much less expensive for borough residents and businesses. The increase in costs for the conversion alternative in the 2045 to 2050 time period is for replacing the furnaces and boilers which were installed in the 2015 to 2020 time period and which are assumed to have a 30-year operating life from the time when the structure is converted to use natural gas or propane. The status quo alternative also has boiler or furnace replacement but those have been installed over many years and thus 1/30 (30-year replacements) of the housing stock is assumed to have boilers or furnaces replaced each year.

8.1.2 Benefit-Cost Ratio Sensitivity Analysis

A probability-based sensitivity analysis was conducted for the benefit-cost ratio. As noted earlier, a benefit-cost ratio that exceeds one indicates that from a societal perspective the investment should be undertaken. The benefit ratios are very robust for both the private and public entities, and even with the sensitivity analysis the ratios remain well above one. The public entity has a slightly higher mean benefit-cost ratio of about 2.01 while the private sector entity has a mean ratio of about 1.95.

Figure 20. Sensitivity Analysis of Benefit-Cost Ratio



Private **Public/Other**

Source: Northern Economics, Inc.

9 Contingencies

The Request for Proposals identified a number of tasks to be addressed in the Contingencies Section of the report. These tasks included:

- Listing any and all assumptions and critical parameters for the work
- Sensitivity analyses focused on the effects of changes in assumptions or parameters
- Identify and characterize the tasks required to prepare the FNSB for implementation of a distribution system design

In preparing this report the Consultant Team came to the conclusion that the assumptions should be placed in context of the items for which they were used rather than be listed in a section that did not provide context for them. Similarly, the sensitivity analyses were considered to be more useful in proximity to the analytical results. Implementation of a distribution system design is addressed in subsections of this section.

The following paragraph provides the reader with the relevant report sections where the assumptions and sensitivity analyses are discussed in the report.

- Listing any and all assumptions and critical parameters for the work
  - 2 Market Estimate
  - 3.1 Pipeline Layout
  - 3.2.1 Basis for Initial Estimate
  - 6.2.1 Model Inputs
  - 8.1.1 Natural Gas/propane Distribution System
- Sensitivity analyses focused on the effects of changes in assumptions or parameters
  - 2.7 Market Sensitivity Analysis
  - 6.3 Cost of Service Sensitivity Analysis
  - 7 Consumer Savings
  - 8.1.2 Benefit-Cost Ratio Sensitivity Analysis

9.1 Implementation

An important early issue is identifying what organization is best suited to meet FNSB's needs. A private firm may be able to respond more quickly, and that response should be carefully compared to the ultimate costs between the private and public forms of organization. Cost-of-service estimates suggest a private entity will have a higher cost of service under the given assumptions of debt financing, interest rates, and income taxes.

The ability of one or the other types of organizations to obtain financing may heavily weight this decision, especially if grant finances can be obtained or if some form of public corporation can be established. Financial sensitivity analysis suggests actual capital costs are the most influential factor for project financial success.

9.2 Pre-Construction Tasks

Baker engineers developed the main tasks required to prepare the FNSB for implementation of a distribution system design, as discussed in the following sections.

9.2.1 Preliminary Engineering and Detailed Design

The initial efforts will include preparing an RFP, soliciting proposals, and selecting an offeror to provide professional services related to the natural gas distribution line development. The professional services are expected to include engineering, surveying, environmental studies, permitting, right-of-way activities, and construction bid package preparation. The entire solicitation and selection effort could last four months.

Potential impacts to the schedule for this effort could include funding limitations and protracted negotiations. Funding limitations could prevent all of the professional services work from being contracted under a single solicitation. Multiple solicitations or contract amendments may extend the project schedule. Potential funding limitation impacts can be mitigated by developing a plan to address a scenario requiring multiple solicitations or contract amendments.

Protracted negotiations for professional services could also extend the schedule. Multiple iterations of fee proposals and scopes of work may create delays. The potential schedule impacts can be mitigated by developing a clear and explicit RFP and scope of work as well as an independent cost estimate before beginning negotiations.

The preliminary engineering and detailed design efforts are expected to last one year. Potential impacts to this schedule include changes in scope or anticipated construction funding. The schedule impacts can be mitigated by minimizing changes to the scope and ensuring that the proposed design is consistent with available construction funding.

9.2.2 Permitting, Environmental Studies

Permitting the construction and operation of the gas distribution lines in the FNSB could take a year if the preparation of a NEPA document is required. Federally funded or permitted projects require completion of a NEPA document. For this project, an Environmental Assessment is likely sufficient. Long lead time permits with the ability to impact the schedule include Bureau of Land Management (BLM) ROW and temporary land use permit, U.S. Army and U.S. Air Force construction permits, Bureau of Indian Affairs (BIA) Revocable Use Permit and ROW to cross Native allotments, and U.S. Army Corps of Engineers Section 404/10 permit for wetlands and stream crossings.

The BLM is the federal land owner and will issue permits for construction through Eielson Air Force Base and Fort Wainwright Army Post. Military Base and Post Commanders must approve project construction, and a change of command during permitting could significantly impact the schedule. The BIA Revocable Use Permit must be obtained prior to conducting field work on Native allotments. This permit and the ROW across allotments require input from the original allottee or all of their heirs if the allottee has passed away. Locating heirs can be time consuming and should be considered long lead time permits.

Wetland, raptor, fisheries and cultural resources studies may be required if information on potential effects on those resources does not exist for the project area. These studies must be conducted during the growing season. If winter construction is proposed, then a winter fisheries study may be required. These usually occur in February or March. Generally, field studies will require land owner permits or permission. Surveys using a drill rig or loader usually take longer to permit than surveys conducted with hand-held equipment.

9.2.3 Rights-of-Way Activities

ROW activities are estimated to last about nine months. This duration assumes that the new pipeline will follow existing roads and can be placed within existing utility easements or within new easements within existing road ROW. The only new ROW required will be for the gate and regulator stations. The siting of the stations is somewhat flexible, and consequently they can be located to minimize ROW acquisition efforts. The schedule for this activity could be adversely impacted if any new ROW requires an eminent domain or condemnation process where ROW is acquired from an unwilling land owner. Condemnation could extend the duration of this effort to two years or longer.

9.2.4 Contract Negotiation

There are several main steps required for successful contract negotiation, presented below.

Bidding and Source Selection

Construction bidding and source selection activities could last about three months. Potential schedule impacts include funding limitations, inaccurate construction cost estimates, and a limited pool of contractors and fabricators. Funding limitations and inaccurate construction cost estimates together could create delays if the construction bids come in much higher than the available funding (which should be based on construction cost estimates). High bids may require the project to be de-scoped to meet available funding, which will extend the time required to complete the construction bidding and source selection activities.

A limited pool of contractors and fabricators could also delay the project. This risk is likely limited to the large diameter steel transmission pipeline and the gate and regulator stations. This work requires specialized skills, and the pool of available resources is more limited than it is for the smaller diameter plastic pipe. Several North Slope projects currently under development could further limit the pool of contractors and fabricators available to the project.

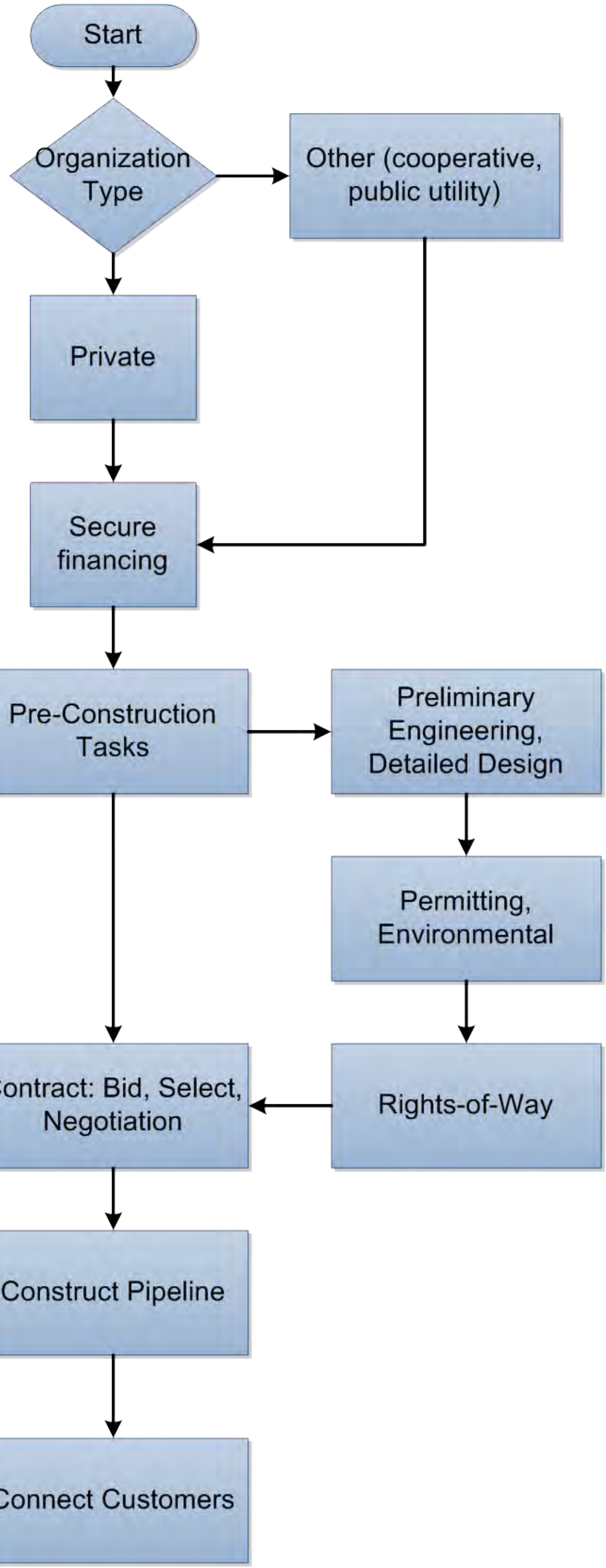
9.3 Pipeline Construction

Pipeline construction is expected to last about one and one-half years. This duration assumes that construction will begin in the spring of year one and continue through to the fall of year two, with a period of winter shutdown as required. Potential schedule impacts include changed site conditions, weather delays, and limited contractor resources.

Changed site conditions could result from numerous sources such as unanticipated soil conditions, frozen soils, contaminated soils, and unknown utilities. Unusual weather, including excessive rain, snow, or cold could delay the project. Alternatively, unusually dry and warm weather could also allow a contractor to complete the work more quickly. Another item that could impact the schedule is if the selected contractors have other contracts that could limit their resources available to the project.

Figure 21 provides a graphic representation of the process described above.

Figure 21. Potential Gas Distribution System Flowchart



10 Air Quality

Conversion of heating system fuels such as wood, oil, and coal to natural gas will reduce the emissions of criteria air pollutants in the Fairbanks area. Criteria pollutants are regulated pollutants under the Clean Air Act, and include oxides of nitrogen (NO_X), carbon monoxide (CO), particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}), particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$), sulfur dioxide (SO_2), and volatile organic compounds (VOC).

An analysis has been prepared to estimate the annual amount of criteria pollutants emitted from the heating systems for existing residential and commercial buildings in the FNSB. Emissions from facilities in the industrial sector, as described in Section 2, are not included in this analysis. Table 21 provides a summary of the estimated current emissions from these sources, distributed between the high, medium, and low-demand areas as described in Section 2.4. Note that the high and medium-demand zones together approximate the area designated as the $PM_{2.5}$ nonattainment area.

Table 21. Summary of Existing Emission Estimates in the FNSB, by Zone

Zone	Category	NO_X (tpy)	CO (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	SO_2 (tpy)	VOC (tpy)
High	Residential	399	12,672	1,505	1,294	452	9,592
	Commercial	347	203	59	54	534	10
	Total	746	12,875	1,564	1,348	986	9,602
Medium	Residential	278	8,815	1,047	900	315	6,672
	Commercial	61	36	10	10	94	2
	Total	339	8,851	1,057	909	409	6,674
Low	Residential	83	2,679	318	274	96	2,028
	Commercial	24	114	6	5	36	4
	Total	108	2,793	324	279	131	2,033
Overall	Residential	760	24,166	2,871	2,467	863	18,292
	Commercial	433	353	75	68	664	16
	Total	1,193	24,519	2,946	2,536	1,526	18,308

Source: SLR International Corp 2012
Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

The residential emissions estimates were calculated using data from the 2010 Fairbanks Home Heating Survey report, prepared by Sierra Research for the Alaska Department of Environmental Conservation. This survey estimated the number of residential heating devices, types of fuel used, and amount of fuel used in the $PM_{2.5}$ nonattainment area. Four categories of fuel are used for space heating in residential buildings: wood, oil, coal, and natural gas. The oil category includes fuel oil, diesel, and kerosene. The same fuels are used for space heating in commercial buildings. Fuel combustion efficiency varies depending on the type of heating device used and the fuel being combusted. Existing emissions were calculated by applying the fuel use ratios to the demand estimates discussed in Section 6.2.1 (in terms of Btu of natural gas input), adding the existing natural gas consumption to the fuel use tally, adjusting the demand for each fuel based on the average combustion efficiency of that fuel compared to natural gas, and converting the heat input demand into fuel consumption for each of the fuel categories. Demand in the low zone is discussed in Section 6.2.1 in terms of propane. The heat demand in this zone was originally calculated in terms of Btu of natural gas input; therefore, the low zone demand numbers did not require additional adjustment prior to the emission calculations.

Annual emission estimates were calculated using an EPA reference document, AP-42, Compilation of Air Pollutant Emission Factors, Section 1 (EPA 2010). Emission estimates for PM_{10} and $PM_{2.5}$ may differ from the PM emissions in the analyses being prepared as part of the $PM_{2.5}$ State Implementation Plan (SIP). The FNSB and the contractor preparing the SIP analyses, Sierra Research, are currently in the final stages of development of Alaska-specific PM emission factors. These emission factors are based on source testing of commonly used heating devices and locally available fuels in the FNSB. Preliminary discussions indicate that the Alaska-specific PM emission factors may be substantially lower than the PM emission factors provided in AP-42.

The same method described above was used to calculate the emission estimates for the commercial sources, except the fuel type use data were provided by Sierra Research (Sierra Research 2010). Wood was not included in the fuel type use data for commercial sources. The calculation method assumes that the fuel use ratio is the same in the high, medium, and low-demand zones.

10.1 Non-attainment Area

Particulate matter is a pollutant of special concern in the Fairbanks area. Exceedances of the ambient air quality standard for $PM_{2.5}$ have been measured in Fairbanks. As a result, EPA has designated portions of the Fairbanks and North Pole areas as a nonattainment area for $PM_{2.5}$. This nonattainment area is portrayed in Figure 2. Because of the very small size of the particle, $PM_{2.5}$ can reach deeply into human respiratory systems and cause or aggravate serious health problems, including asthma, bronchitis, and heart attacks. $PM_{2.5}$ can be emitted directly from sources of combustion and can also form when gases emitted by combustion react in the air (EPA 2012).

The nonattainment designation for the Fairbanks area is a cause for concern for several reasons. First, the local population is at increased risk for respiratory and circulatory health problems. Secondly, the designation negatively affects economic growth in the area. Air quality permits for any commercial or industrial activity cannot be obtained if the activity will increase the amount of $PM_{2.5}$ emissions over current amounts. Because of this restriction, growth of existing commercial and industrial activity will likely not occur, and new commercial and industrial activities will likely not take root in the Fairbanks area, until EPA is satisfied that compliance with the ambient $PM_{2.5}$ standard is attained and a plan is in place to maintain compliance with the ambient standard.

Natural gas conversion in Fairbanks will reduce the emissions of $PM_{2.5}$ from residential and commercial facilities. The conversion to natural gas will also reduce NO_X and SO_2 emissions, which are precursors to the formation of secondary $PM_{2.5}$ in the atmosphere. The reduction will help bring the Fairbanks area into attainment with the ambient $PM_{2.5}$ air quality standard. The reduction in emissions is discussed further in Section 10.2.

10.2 Potential Impacts, Conversion to Natural Gas

SLR International Corp's analysis estimates the change in emissions resulting from conversion of the three demand zones to natural gas over a period of six years. The emissions calculations assume that the rate of conversion for each original fuel type is the same except in the low-demand zone, where demand modeling indicates that residential wood burners will likely not begin converting to propane prior to 2021. In the low-demand zone, the emissions calculations assume that residential conversions from coal and oil occur at the same rate, while residential conversion from wood combustion does not occur during the six years of the scenario. The emission calculations also assume that the existing use of natural gas supplied by FNG remains constant during the years of the analysis. Results of the analysis are shown in Table 22 through Table 24.

Table 22. Estimated Annual Emissions (tpy) After Conversion in the High-Demand Zone, 6-Year Conversion

Pollutant	Category	Existing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
NO_X	Residential	399	391	355	279	216	172	160
	Commercial	347	330	281	227	199	198	199
	Total	746	721	636	506	415	369	360
CO	Residential	12,672	12,166	10,268	6,389	3,093	795	152
	Commercial	203	199	187	172	165	166	168
	Total	12,875	12,366	10,454	6,562	3,258	961	319
PM_{10}	Residential	1,505	1,445	1,221	761	371	99	23
	Commercial	59	54	40	24	16	15	15
	Total	1,564	1,499	1,260	785	387	114	38
$PM_{2.5}$	Residential	1,294	1,242	1,049	655	320	86	21
	Commercial	54	49	37	23	15	14	15
	Total	1,348	1,292	1,086	678	335	101	36
SO_2	Residential	452	434	366	227	109	27	4
	Commercial	534	471	301	112	14	1	1
	Total	986	905	668	340	123	28	5
VOC	Residential	9,592	9,207	7,763	4,816	2,309	563	73
	Commercial	10	10	10	11	11	11	11
	Total	9,602	9,217	7,774	4,826	2,320	574	84

Source: SLR International Corp 2012

Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

Table 23. Estimated Annual Emissions (tpy) After Conversion in the Medium-Demand Zone, 6-Year Conversion

Pollutant	Category	Existing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
NO_X	Residential	278	280	249	200	158	129	122
	Commercial	61	62	50	40	35	35	35
	Total	339	343	299	240	193	164	157
CO	Residential	8,815	8,904	7,250	4,714	2,560	1,060	644
	Commercial	36	36	33	30	29	29	30
	Total	8,851	8,940	7,283	4,745	2,589	1,089	673
PM_{10}	Residential	1,047	1,058	862	562	306	129	80
	Commercial	10	11	7	4	3	3	3
	Total	1,057	1,068	869	566	309	132	82
$PM_{2.5}$	Residential	900	909	741	483	264	112	69
	Commercial	10	10	6	4	3	3	3
	Total	909	919	747	487	267	114	72
SO_2	Residential	315	318	259	168	91	37	22
	Commercial	94	95	53	20	2	0	0
	Total	409	413	312	188	93	37	22
VOC	Residential	6,672	6,740	5,482	3,555	1,917	777	460
	Commercial	1.8	1.8	1.8	1.9	1.9	1.9	1.9
	Total	6,674	6,741	5,484	3,557	1,919	779	462

Source: SLR International Corp 2012
Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

Table 24. Estimated Annual Emissions (tpy) After Conversion in the Low-Demand Zone, 6-Year Conversion

Pollutant	Category	Existing	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
NO_X	Residential	83	81	74	67	60	58	58
	Commercial	24	20	17	13	12	12	12
	Total	108	101	91	81	72	70	70
CO	Residential	2,679	2,665	2,588	2,509	2,428	2,410	2,434
	Commercial	114	12	11	10	10	10	10
	Total	2,793	2,677	2,599	2,519	2,438	2,420	2,444
PM_{10}	Residential	318	320	321	321	321	323	327
	Commercial	6	3	2	1	1	1	1
	Total	324	324	323	322	322	324	328
$PM_{2.5}$	Residential	274	275	276	276	276	278	281
	Commercial	5	3	2	1	1	1	1
	Total	279	278	278	277	277	279	281
SO_2	Residential	96	88	68	47	26	18	18
	Commercial	36	28	17	5	0	0	0
	Total	131	116	85	52	26	18	18
VOC	Residential	2,028	2,047	2,064	2,081	2,098	2,117	2,139
	Commercial	4	1	1	1	1	1	1
	Total	2,033	2,048	2,065	2,081	2,098	2,118	2,139

Source: SLR International Corp 2012
Note: All emissions are in terms of tons of pollutant emitted per year (tpy).

Table 25 through Table 27 provide the overall estimated percentage change in emissions for residential and commercial facilities in each of the demand zones. The slight increases in VOC emissions in the commercial sector in the high and medium-demand zones are caused by the increased combustion of natural gas. The slight increases in residential PM_{10}, $PM_{2.5}$, and VOC emissions in the low-demand zone are due to continued combustion of wood fuel.

Table 25. Change in Emissions Due to Conversion in the High-Demand Zone

Category	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	VOC
	(%)					
Residential	-60	-99	-98	-98	-99	-99
Commercial	-43	-18	-74	-73	-100	8
Total	-52	-98	-98	-97	-99	-99

Source: SLR International Corp 2012

Table 26. Change in Emissions Due to Conversion in the Medium-Demand Zone

Category	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	VOC
	(%)					
Residential	-56	-93	-92	-92	-93	-93
Commercial	-43	-18	-74	-73	-100	8
Total	-54	-92	-92	-92	-95	-93

Source: SLR International Corp 2012

Table 27. Change in Emissions Due to Conversion in the Low-Demand Zone

Category	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	VOC
	(%)					
Residential	-30	-9	3	3	-82	5
Commercial	-51	-91	-85	-83	-100	-85
Total	-35	-12	1	1	-86	5

Source: SLR International Corp 2012

Table 28 shows the percent reduction in emissions by fuel type for residential structures in the high and medium-demand zones, demonstrating that conversion of residential heating systems from wood-fired to natural gas-fired has a greater effect on emissions reductions of all pollutants except NO_X and SO_2. The emissions of these two pollutants are reduced more effectively by conversion of oil-fueled systems to natural gas. In the residential sector, conversion from wood-fired systems to natural gas-fired systems results in 95 percent of the $PM_{2.5}$ emission reductions.

Table 28. Contribution to Emission Reductions from Residential Structures, By Fuel Type In the High and Medium-Demand Zones

Fuel Type	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	VOC
	(%)					
Wood	27	83	95	95	4	99
Oil	55	0	1	2	83	0
Coal	18	17	3	3	13	1

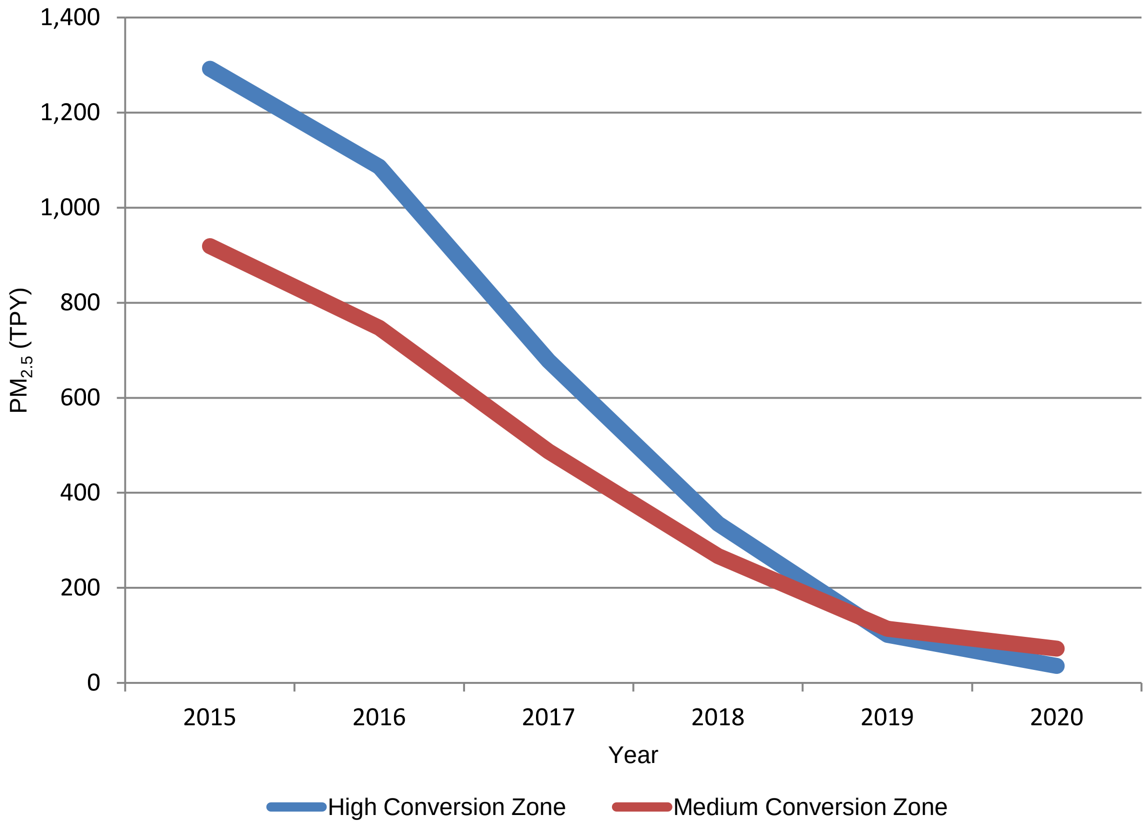
Source: SLR International Corp 2012

Note: Percent reductions for each pollutant may not total 100 percent due to rounding.

SLR also prepared a brief companion analysis to estimate the change in emissions if residential and commercial structures in the high and medium-demand zones that use wood or coal for space heating do not convert to natural gas-fired systems as anticipated in the model. The analysis assumed zero growth in the use of wood and coal fuels, and that conversion from oil-fueled to natural gas-fired systems occurs as the demand model predicts. $PM_{2.5}$ emissions from the commercial sector would still decrease significantly because the majority of commercial structures are heated with oil-fueled systems. However, $PM_{2.5}$ emissions from the residential sector would decrease by less than one percent in this scenario. This companion analysis makes clear that conversion of residential heating systems from wood-fired and coal-fired to natural gas-fired is essential to achieving reductions in $PM_{2.5}$ emissions.

The main analysis demonstrates that converting to natural gas use for heating will reduce the overall emissions of $PM_{2.5}$ in the Fairbanks area. Figure 22 illustrates the estimated change in $PM_{2.5}$ emissions from residential and commercial sources in the high and medium-demand zones.

Figure 22. $PM_{2.5}$ Emissions Estimates, High and Medium-Demand Areas, 2015 to 2020, in Tons of Pollutant per Year.



Source: SLR International

The conversion to natural gas will also reduce NO_X and SO_2 emissions, which are precursors to the formation of secondary $PM_{2.5}$ in the atmosphere. These emission reductions will help bring the Fairbanks area into attainment with the ambient $PM_{2.5}$ air quality standard.

The emissions reductions presented here reflect the changes associated with the piped natural gas systems in the high and medium-demand areas and propane systems in the low-demand area.

10.3 Ice Fog Implications

Ice fog is a weather condition that can occur during winter cold snaps of approximately -30 degrees Fahrenheit and colder. The Fairbanks area normally experiences several cold periods each winter during which ice fog forms and limits visibility. Ice fog forms when water vapor is emitted into very cold air that has a relative humidity at or close to 100 percent. The water vapor cools rapidly and forms tiny ice particles, which make up the fog. Because Fairbanks already experiences ice fog events each winter, SLR prepared an analysis to determine the amount of additional water vapor that would be emitted during combustion of natural gas compared to other fuels used in the local area. SLR determined the moisture content of wood, wood pellets, oil, natural gas, and coal, and developed approximate chemical formulas for each fuel. Combustion of fuel produces water vapor and carbon dioxide. A ratio of water vapor produced per the amount of fuel combusted can be obtained by balancing the chemical equation of combustion for each fuel.

Natural gas-fired boilers and furnaces appropriate for residential and commercial use are classified as either condensing units or non-condensing units. Condensing units do not emit as much water vapor in the exhaust because the vapor is condensed and drained from the unit. Initial research indicates that condensing units may not be the better option for use in the Fairbanks area due to the low but constant rate of water drainage, which can produce ice dams in drain or sewer lines, and due to the intake air temperature requirements of these units. This analysis does not account for condensation of water vapor prior to exhaust.

SLR determined that natural gas combustion will produce a greater mass of water vapor per heat input than oil, coal, and wood pellets. The results of this analysis are provided in Table 29.

Table 29. Water Vapor Emission Analysis

Fuel Type	Heating Value (MMBtu/ton)	Water Produced Per Mass of Fuel (%)	Water Produced per Fuel Input (ton water/MMBtu fuel)
Oil	37.4	138	3.7
Coal	15.3	60	3.9
Wood Pellets	13.9	60	4.3
Natural Gas	48	225	4.7
Wood	5.0	68	13.5

Source: SLR International Corp 2012

If the Fairbanks area converts many of the existing space heating emission units to natural gas combustion, water vapor emissions will likely increase. These additional water vapor emissions do not necessarily mean that ice fog events will become more common, because the frequency of the meteorological conditions that trigger ice fog events will not increase. However, the ice fog events that do occur may have slightly longer duration and may cover a slightly larger geographic area.

The local exceedances of the ambient $PM_{2.5}$ air quality standard (excluding wildfire smoke events) occur during these same cold snaps. Carl S. Benson stated it clearly that "the air pollution over Fairbanks during cold spells couldn't be worse, because the mechanisms for cleaning the air are virtually eliminated while all activities which pollute the air are increased." (Benson 1965). Conversion to natural gas-fired space heating systems to lower $PM_{2.5}$ emissions in the Fairbanks area in pursuit of achieving attainment with the ambient air quality standard for $PM_{2.5}$ is not expected to have a significant negative effect on ice fog events.

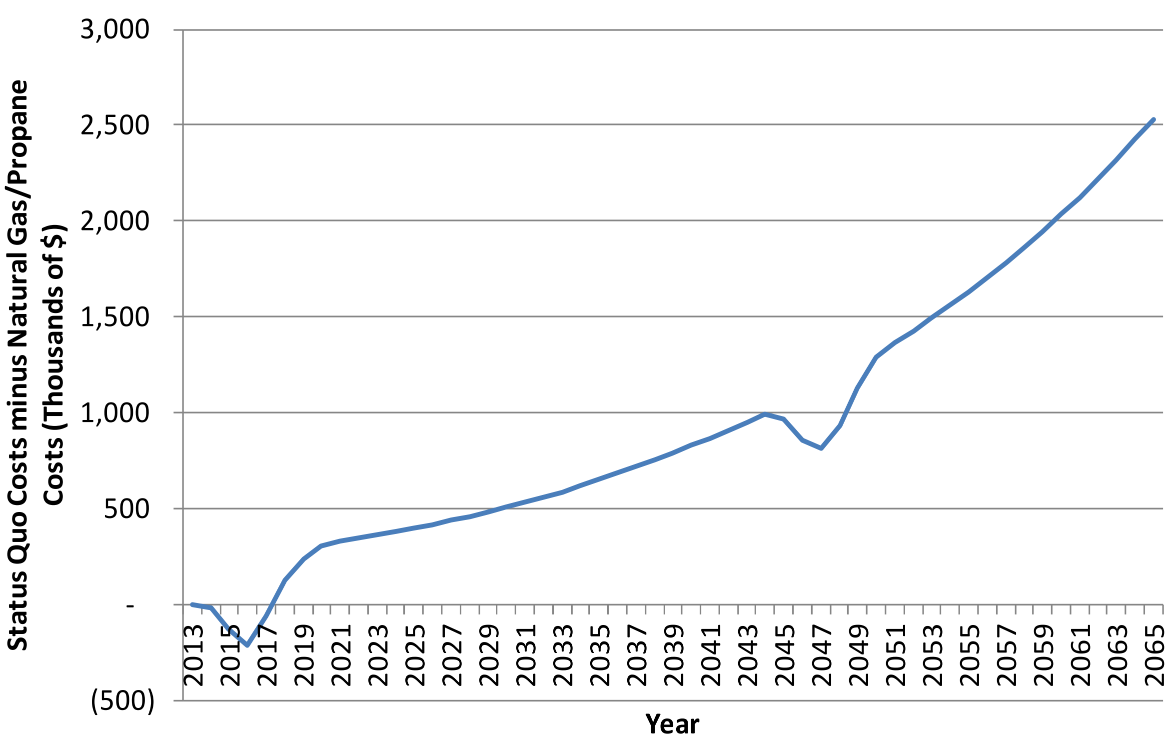
11 Decision Points

The purpose of this report section is to identify if there were zones or areas where the costs of converting to natural gas and propane were greater than the costs of using distillates and wood. As noted in the BCA discussion (Section 8), the benefit-cost ratio for each of the three density areas (high, medium, and low) is positive, so there is no need to phase the project or to not undertake development of the distribution system in any area.

The large number of assumptions and variables employed in the modeling effort, and the potential management responses to changes in costs make it difficult to identify points where decisions would be made to not proceed with the project. For example, if the cost of natural gas exceeded $10 per MMBtu in 2015 sponsors of the gas distribution system could seek to obtain additional grants to reduce capital expenditure or seek grants to be used as operating funds and subsidize the cost to the consumer until sufficient volumes of gas reduce the per unit cost. Similar responses could be undertaken to mitigate other adverse changes in assumptions or costs.

On a borough-wide basis the costs of converting to natural gas/propane are less than the costs of continuing with the status quo through 2065. As is typical of any project with large upfront capital investments the costs associated with the conversion to natural gas/propane are greater in the initial years and then in later years the fuel cost savings associated with natural gas/propane result in lower costs to local residents and businesses compared to distillates and wood. Figure 23 shows the net difference (annual status quo costs less natural gas/propane costs) in the stream of costs for the two different fuel alternatives. The cumulative net value turns positive in 2018 and continues to increase over time. The drop beginning in 2045 is replacing all of the gas-fired boilers and furnaces that were converted in the 2015 to 2020 time period.

Figure 23. Cost Differential Between Alternatives



Source: Northern Economics, Inc.

The model indicates that wood switching will not occur in the high and medium density areas for several years depending on the specific model assumptions that are used. In most model runs the wood switching does not occur until 2021 or so, when the volume of gas sales has increased to the point where the fixed costs can be spread across greater gas sales volumes. Substantial increases in the amount of grants to the project can reduce the date by two or three years but another approach would be to obtain grants that could be used as operating funds and employed to reduce the sales price for the first five or six years until the conversions are generally complete or the sales volumes enable gas to compete with wood.

The model also indicates that propane can displace fuel oil in the low density area but is unlikely to cause residents using wood heat to switch to propane. This may not be an issue since there are relatively few structures in the low density areas and they are widely dispersed. However, it does mean that this group may not benefit from the energy investment available to other residents.

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Appendix A. Project Maps

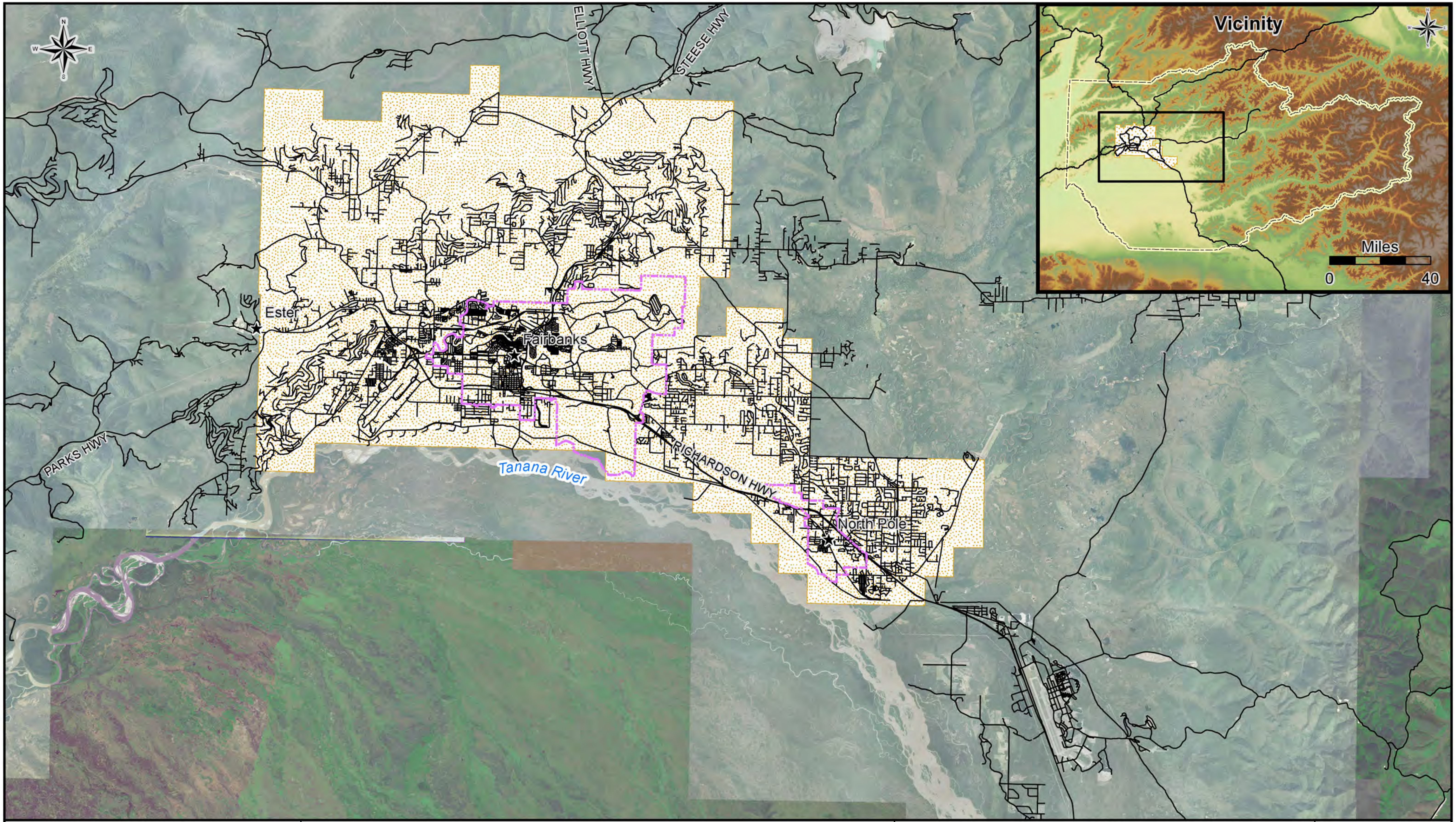

Figure 2
Existing PM2.5
Non-Attainment Area

SCALE 1 in = 3 miles

DATE 06/26/2012

Baker

Legend

Roads
City Boundary
Borough Boundary
PM2.5 Non-Attainment Area

Fairbanks North Star Borough
Gas Distribution Analysis

0 1.5 3 6 Miles

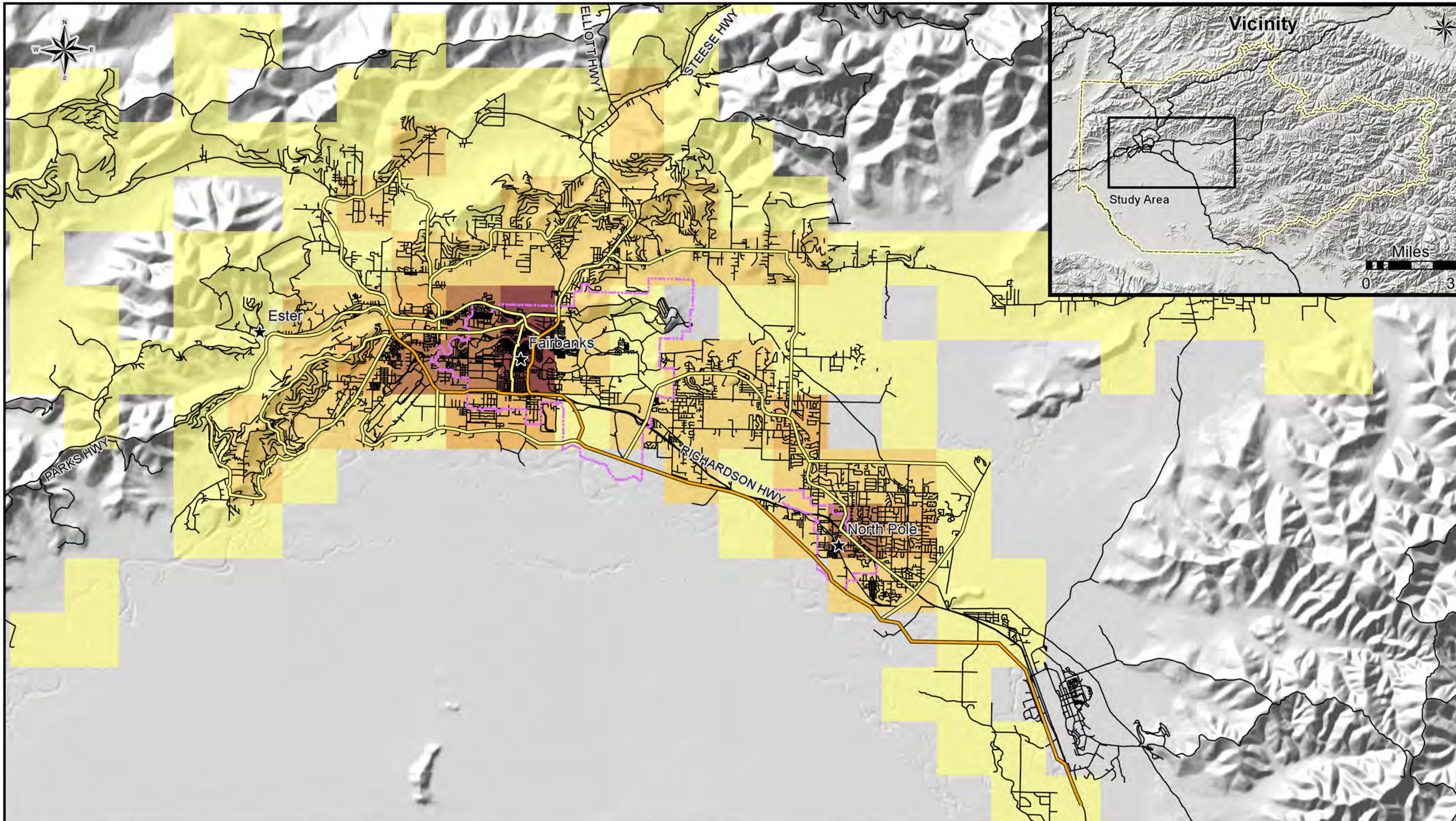

Figure 3
Estimated Combined
Residential and Commercial Demand

SCALE 1 in = 3 miles

DATE 6/26/2012

Baker

Legend

City Boundary
Borough Boundary
Roads

Network Pipelines
Distribution Pipeline
Transmission Pipeline

MMBtu/Year
65 - 45,763
45,763 - 164,578
164,578 - 370,219
370,219 - 744,942
744,942 - 1,165,364

Fairbanks North Star Borough
Gas Distribution Analysis

Miles 0 1.5 3 6

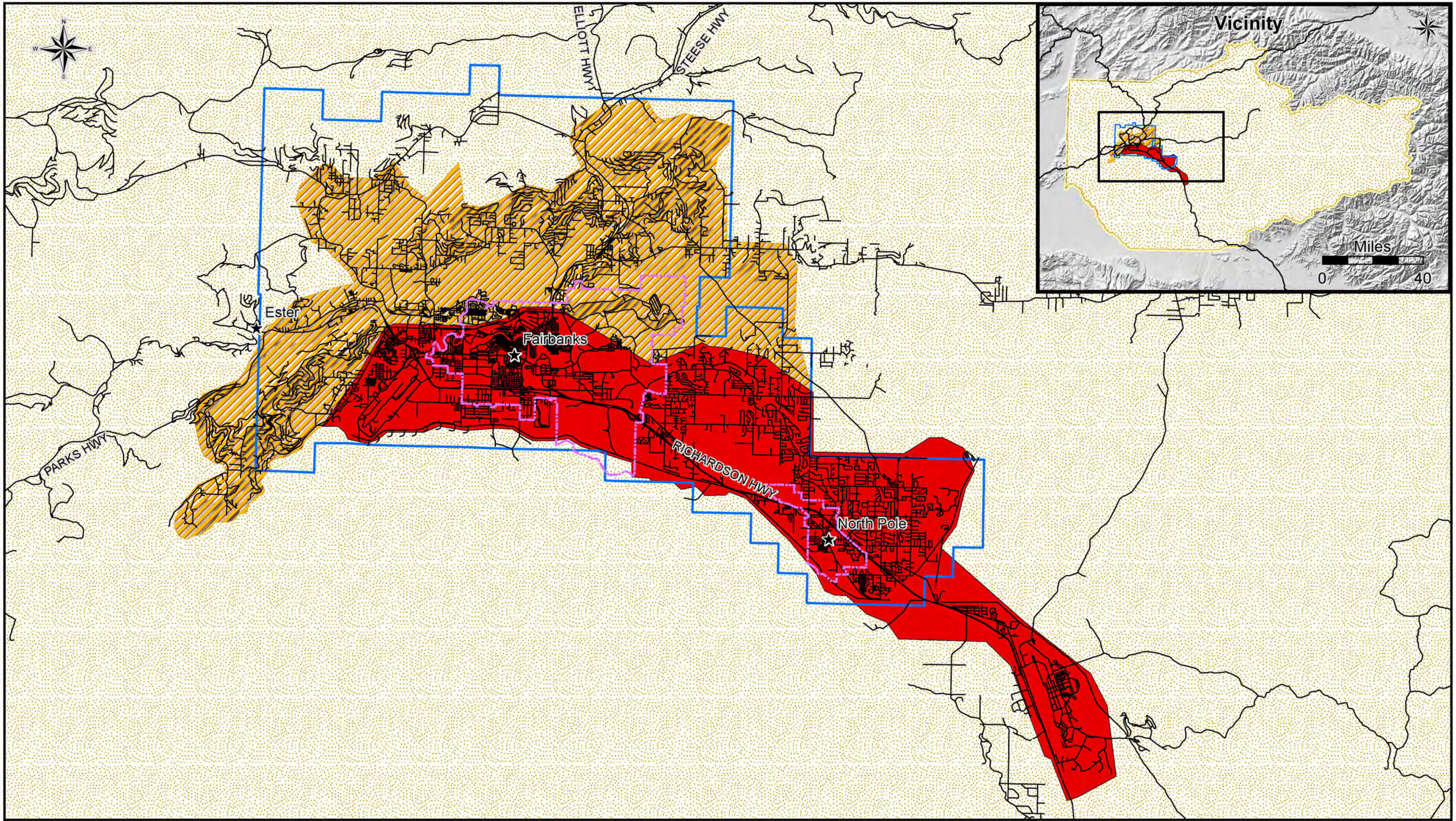

Figure 4
High, Medium, and Low Demand Areas

SCALE	1 in = 3 miles
DATE	06/26/2012

Baker

Legend

- Roads
- City Boundary
- Borough Boundary
- PM2.5 Non-Attainment Area
- High Demand
- Medium Demand
- Low Demand

Fairbanks North Star Borough
Gas Distribution Analysis

Miles 0 1.5 3 6

FAIRBANKS NORTH STAR BOROUGH January 1, 1964

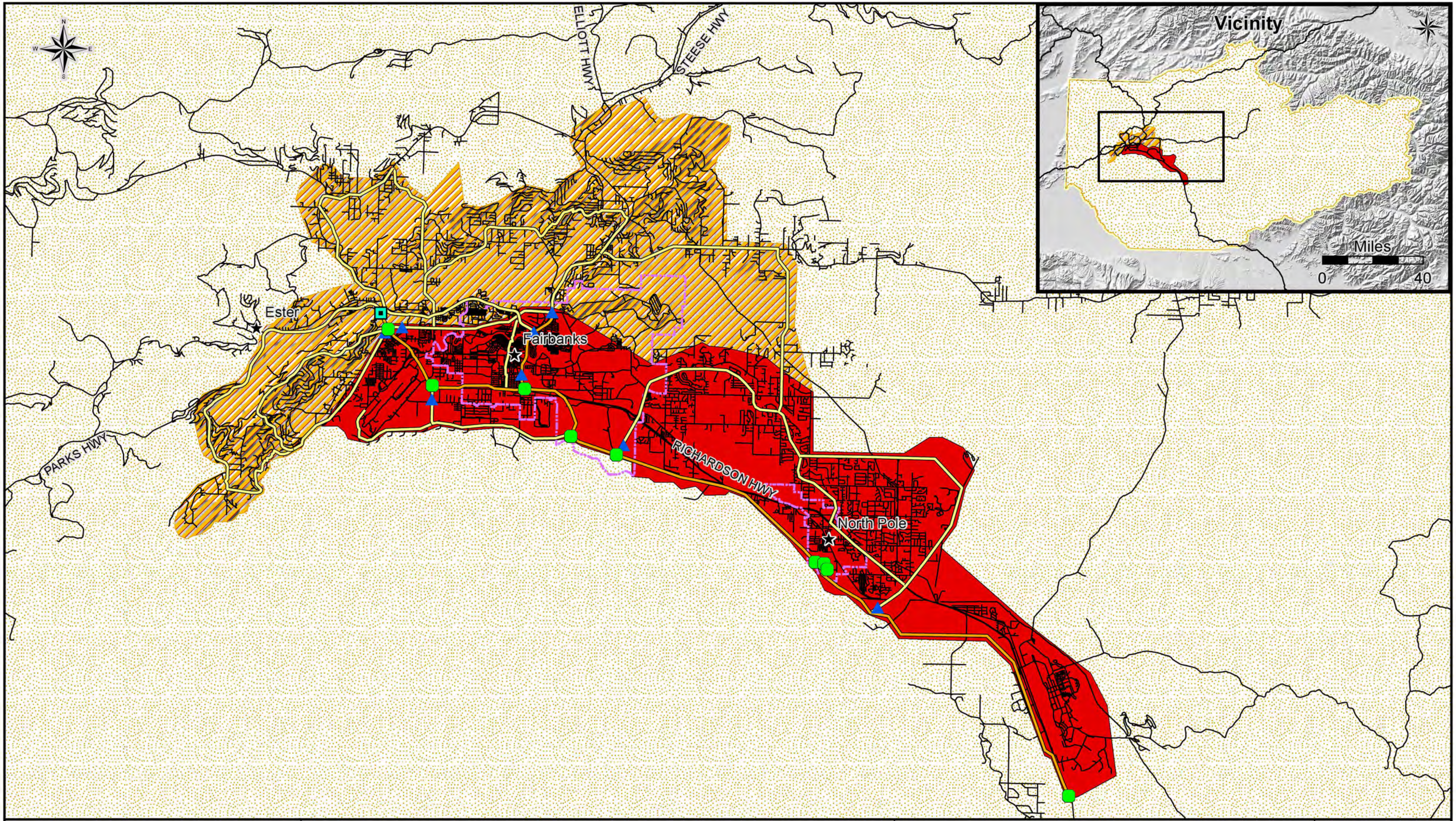

Figure 7
High, Medium, and Low Demand Areas

SCALE	1 in = 3 miles
DATE	06/26/2012

Baker

Legend

- Gas In Point
- Reg Station
- Gate Station
- Distribution Pipeline
- Transmission Pipeline
- Roads
- City Boundary
- Borough Boundary
- High Demand
- Medium Demand
- Low Demand

Fairbanks North Star Borough
Gas Distribution Analysis

0 1.5 3 6 Miles

FAIRBANKS NORTH STAR BOROUGH January 1, 1964

Appendix B. Basis of Cost Estimation (Michael Baker, Jr. Inc.)

Fairbanks North Star Borough: Gas Distribution System Analysis **Date: June 25, 2012**
Fairbanks, Alaska

FINAL COST ESTIMATE SUMMARY: PIPELINE LAYOUT NETWORK

	Length [LF]	Length [Miles]	Construction Cost	Materials	Engineering	Permitting	Total Cost	Cost/Foot	Cost/Mile
HIGH DEMAND AREA									
Pipelines									
Transmission lines	*184,644*	*35*	*$ 29,232,000*	*$ 11,122,000*	*$ 2,018,000*	*$ 15,000*	*$ 42,387,000*	*$ 230*	*$ 1,212,000*
Distribution feeder lines	*275,435*	*52*	*$ 17,852,000*	*$ 3,840,000*	*$ 1,085,000*	*$ 23,000*	*$ 22,800,000*	*$ 83*	*$ 437,000*
Distribution lines	*2,311,922*	*438*	*$ 57,798,000*	*$ 15,783,000*	*$ 3,679,000*	*$ 191,000*	*$ 77,451,000*	*$ 34*	*$ 177,000*
Service lines	*852,375*	*161*	*$ 21,309,000*	*$ 11,138,000*	*$ 1,622,000*	*$ 71,000*	*$ 34,140,000*	*$ 40*	*$ 211,000*
Pig Launcher and Receiver			*$ -*	*$ 600,000*	*$ 180,000*	*$ -*	*$ 780,000*		
Unknown Costs (30%)			*$ 37,857,000*	*$ 12,745,000*	*$ 2,575,000*	*$ 90,000*	*$ 53,267,000*		
Subtotal	3,624,375	686	$ 164,048,000	$ 55,228,000	$ 11,159,000	$ 390,000	$ 230,825,000	$ 64	$ 336,000
SUBTOTAL COST RANGE (-30% to +50%):							**$161,600,000 to $346,200,000**		
MEDIUM DEMAND AREA									
Pipelines									
Transmission lines	*-*	*-*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*	*$ -*
Distribution feeder lines	*348,820*	*66*	*$ 17,441,000*	*$ 4,748,000*	*$ 1,109,000*	*$ 19,000*	*$ 23,317,000*	*$ 67*	*$ 353,000*
Distribution lines	*2,607,980*	*494*	*$ 65,200,000*	*$ 10,125,000*	*$ 3,766,000*	*$ 139,000*	*$ 79,230,000*	*$ 30*	*$ 160,000*
Service lines	*808,500*	*153*	*$ 20,213,000*	*$ 8,975,000*	*$ 1,459,000*	*$ 43,000*	*$ 30,690,000*	*$ 38*	*$ 200,000*
Pig Launcher and Receiver			*$ -*	*$ -*	*$ -*	*$ -*	*$ -*		
Unknown Costs (30%)			*$ 30,856,000*	*$ 7,154,000*	*$ 1,900,000*	*$ 60,000*	*$ 39,971,000*		
Subtotal	3,765,300	713	$ 133,710,000	$ 31,002,000	$ 8,234,000	$ 261,000	$ 173,208,000	$ 46	$ 243,000
SUBTOTAL COST RANGE (-30% to +50%):							**$121,200,000 to $259,800,000**		
COMBINED HIGH AND MEDIUM DEMAND AREAS									
Total	7,389,675	1,400	$ 297,758,000	$ 86,230,000	$ 19,393,000	$ 651,000	$ 404,033,000	$ 55	$ 289,000
TOTAL COST RANGE (-30% to +50%):							**$282,800,000 to $606,000,000**		

DETAILS: FINAL COST ESTIMATE, PIPELINE LAYOUT NETWORK

HIGH POPULATION DENSITY AREA							
Description	**Class**	**Dia [in]**	**Quantity**	**Unit**		**Unit Cost**	**Total Cost**
1. TRANSMISSION LINES: Provides natural gas to distribution feeder lines and industrial users							
Construction							
Installation Fairbanks to Eielson	ANSI 600	10	168,494	LF		$ 90	$ 15,164,000
Installation Fairbanks towards Fox	ANSI 300	8	16,149	LF		$ 90	$ 1,453,000
Cathodic Protection			35	miles		$ 15,000	$ 525,000
HDD Chena river	varies	varies	1,600	LF		$ 400	$ 640,000
Gate Station	ANSI 600	10	9	EA		$ 1,250,000	$ 11,250,000
Pigging connection	ANSI 600	10	2	EA		$ 50,000	$ 100,000
Pigging connection	ANSI 300	8	2	EA		$ 50,000	$ 100,000
Subtotal-construction							*$ 29,232,000*
Materials							
Materials- Steel pipe, FBE coated	ANSI 600	10	168,494	LF		$ 53	$ 8,930,000
Materials- Steel pipe, FBE coated	ANSI 300	8	16,149	LF		$ 44	$ 711,000
Materials- Valves	ANSI 600	10	4	EA		$ 34,000	$ 136,000
Materials- Valves	ANSI 300	8	2	EA		$ 20,000	$ 40,000
Materials- Design allowance	varies	10 & 8	5%	EA		$ 490,850	$ 491,000
Materials- Misc. Freight			2%	EA		$ 196,340	$ 196,000
Materials- Procurement			4%	EA		$ 412,320	$ 412,000
Materials- SQS			2%	EA		$ 206,160	$ 206,000
Subtotal-materials							*$ 11,122,000*
Launcher/Receiver							
Pig Barrels- mobile	ANSI 600	12	2	EA		$ 300,000	$ 600,000
Subtotal- Transmission Lines			**184,644**	**LF**			**$ 40,954,000**
2. DISTRIBUTION FEEDER LINES: Provides natural gas to local distribution lines							
Construction							
Installation	60psig	6	275,435	LF		$ 50	$ 13,772,000
HDD Chena river	60psig	6	1600	LF		$ 300	$ 480,000
Regulator stations	60psig	6	9	EA		$ 400,000	$ 3,600,000
Subtotal-construction							*$ 17,852,000*
Materials							
Materials- Plastic	60psig	6	275,435	LF		$ 12	$ 3,305,000
Materials- Valves	60psig	6	7	EA		$ 13,300	$ 93,000
Materials- Design allowance	varies	varies	5%	EA		$ 169,900	$ 170,000
Materials- Misc. Freight			2%	EA		$ 67,960	$ 68,000
Materials- Procurement			4%	EA		$ 135,920	$ 136,000
Materials- SQS			2%	EA		$ 67,960	$ 68,000
Subtotal-materials							*$ 3,840,000*
Subtotal- Distribution Feeder Lines			**275,435**	**LF**			**$ 21,692,000**
3. DISTRIBUTION LINES: Provides natural gas to service lines							
Construction							
Residential lines	60 psig	2	2,311,922	LF		$ 25	$ 57,798,000
Subtotal-construction							*$ 57,798,000*
Materials							
Materials- Pipe HDPE	60 psig	2	2,311,922	LF		$ 6	$ 13,872,000
Materials- Valves	60 psig	2	55	EA		$ 6,200	$ 341,000
Materials- Design allowance	varies	varies	5%	EA		$ 710,650	$ 711,000
Materials- Misc. Freight			2%			$ 284,260	$ 284,000
Materials- Procurement			4%			$ 568,520	$ 569,000
Materials- SQS			2%	EA		$ 284,260	$ 6,000
Subtotal-materials							*$ 15,783,000*
Subtotal- Distribution Lines			**2,311,922**	**LF**			**$ 73,581,000**
4. SERVICE LINES: Provides natural gas to individual users							
Construction							
Residential lines- high density	60 psig	0.625	11,160	837,000	LF	$ 25	$ 20,925,000
Commercial lines- high density	60 psig	1	205	15,375	LF	$ 25	$ 384,000
Subtotal-construction							*$ 21,309,000*
Materials							
Materials- Pipe HDPE	60 psig	0.625	11,160	837,000	LF	$ 5	$ 4,185,000
Materials- Pipe HDPE	60 psig	1	205	15,375	LF	$ 5	$ 1,000
Materials- Valves	60 psig	0.625	11,160		EA	$ 500	$ 5,580,000
Materials- Valves	60 psig	1	205			$ 500	$ 103,000
Materials- Design allowance			5%		LF	$ 488,300	$ 488,000
Materials- Misc. Freight			2%		LF	$ 195,320	$ 195,000
Materials- Procurement			4%		LF	$ 390,640	$ 391,000
Materials- SQS			2%		LF	$ 195,320	$ 195,000
Subtotal-materials							*$ 11,138,000*
Subtotal- Service Lines			**852,375**	**LF**			**$ 32,447,000**

DETAILS: FINAL COST ESTIMATE, PIPELINE LAYOUT NETWORK

MEDIUM POPULATION DENSITY AREA							
Description	**Class**	**Dia [in]**	**Quantity**	**Unit**		**Unit Cost**	**Total Cost**
1. TRANSMISSION LINES: Provides natural gas to distribution feeder lines and industrial users							
Construction							
Installation	ANSI 600	10	-	LF		$ 90	$ -
Cathodic Protection			-	miles		$ 15,000	$ -
HDD Chena river	varies	varies	-	LF		$ 400	$ -
Gate Station	ANSI 600	10	-	EA		$ 1,250,000	$ -
Pigging connection	ANSI 600	10	-	EA		$ 50,000	$ -
Pigging connection	ANSI 300	8	-	EA		$ 50,000	$ -
Subtotal-construction							$ -
Materials							
Materials- Steel pipe, FBE coated	ANSI 600	10	-	LF		$ 53	$ -
Materials- Steel pipe, FBE coated	ANSI 300	8	-	LF		$ 44	$ -
Materials- Valves	ANSI 600	10	-	EA		$ 34,000	$ -
Materials- Valves	ANSI 300	8	-	EA		$ 20,000	$ -
Materials- Design allowance	varies	10 & 8	5%	EA		$ -	$ -
Materials- Misc. Freight			2%	EA		$ -	$ -
Materials- Procurement			4%	EA		$ -	$ -
Materials- SQS			2%	EA		$ -	$ -
Subtotal-materials							$ -
Launcher/Receiver							
Pig Barrels- mobile	ANSI 600	12	-	EA		$ 300,000	$ -
Subtotal- Transmission Lines			**-**	**LF**			**$ -**
2. DISTRIBUTION FEEDER LINES: Provides natural gas to local distribution lines							
Construction							
Installation	60psig	6	348,820	LF		$ 50	$ 17,441,000
HDD Chena River	60psig	6	0	LF		$ 300	$ -
Regulator stations	60psig	6	-	EA		$ 400,000	$ -
Subtotal-construction							*$ 17,441,000*
Materials							
Materials- Plastic	60psig	6	348,820	LF		$ 12	$ 4,186,000
Materials- Valves	60psig	6	9	EA		$ 13,300	$ 120,000
Materials- Design allowance	varies	varies	5%	EA		$ 169,900	$ 170,000
Materials- Misc. Freight			2%	EA		$ 67,960	$ 68,000
Materials- Procurement			4%	EA		$ 135,920	$ 136,000
Materials- SQS			2%	EA		$ 67,960	$ 68,000
Subtotal-materials							*$ 4,748,000*
Subtotal- Distribution Feeder Lines			**348,820**	**LF**			**$ 22,189,000**
3. DISTRIBUTION LINES: Provides natural gas to service lines							
Construction							
Residential lines	60 psig	2	2,607,980	LF		$ 25	$ 65,200,000
Subtotal-construction							*$ 65,200,000*
Materials							
Materials- Pipe HDPE	60 psig	2	2,607,980	LF		$ 6	$ 8,734,000
Materials- Valves	60 psig	2	62	EA		$ 6,200	$ 384,000
Materials- Design allowance	varies	varies	5%	EA		$ 455,900	$ 456,000
Materials- Misc. Freight			2%			$ 182,360	$ 182,000
Materials- Procurement			4%			$ 364,720	$ 365,000
Materials- SQS			2%	EA		$ 182,360	$ 4,000
Subtotal-materials							*$ 10,125,000*
Subtotal- Distribution Lines			**2,607,980**	**LF**			**$ 75,325,000**
4. SERVICE LINES: Provides natural gas to individual users							
Construction							
Residential lines- medium density	60 psig	0.625	7,825	782,500	LF	$ 25	$ 19,563,000
Commercial lines- medium density	60 psig	1	260	26,000	LF	$ 25	$ 650,000
Subtotal-construction							*$ 20,213,000*
Materials							
Materials- Pipe HDPE	60 psig	0.625	7,825	782,500	LF	$ 5	$ 3,913,000
Materials- Pipe HDPE	60 psig	1	260	26,000	LF	$ 5	$ 1,000
Materials- Valves	60 psig	0.625	7,825		EA	$ 500	$ 3,913,000
Materials- Valves	60 psig	1	260			$ 500	$ 130,000
Materials- Design allowance			5%		LF	$ 391,350	$ 391,000
Materials- Misc. Freight			2%		LF	$ 156,540	$ 157,000
Materials- Procurement			4%		LF	$ 313,080	$ 313,000
Materials- SQS			2%		LF	$ 156,540	$ 157,000
Subtotal-materials							*$ 8,975,000*
Subtotal- Service Lines			**808,500**	**LF**			**$ 29,188,000**

BASIS OF ESTIMATE

Fairbanks North Star Borough

Natural Gas Distribution System

Preliminary Cost Estimate

March 30, 2012

Michael Baker Jr., Inc.
1400 W. Benson Blvd., Suite 200
Anchorage, AK 99503
907.273.1600

Rev.	Date	Comments	Prepared by:	Checked by:	Approved by:
0	1/24/12	Draft	KMJ	WJO	DMC
1	2/6/12	FNSB Review	KMJ	WJO	DMC
2	3/30/12	FNSB Review	REH	WJO	DMC

TABLE OF CONTENTS

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 1-15% complete, for example a concept study or to evaluate feasibility, an expected accuracy range of +50/-30% is assumed, this is defined as a Class 4 estimate.

The project team members that contributed to the estimate development are shown below.

PROJECT ESTIMATE TEAM LOG			
Name	**Position/Role**	**Affiliation**	**Contact Info**
Derek Christianson, P.E.	PM	MBJ	273-1629
Bill Olzack, P.E.	Estimator QA	MBJ	273-1625
Vin Robinson, P.E.	Estimator	Enstar	230-4464
RaeAnne Hebnes, P.E.	CE/Design	MBJ	273-1618
Katie Johnson	EIT	MBJ	273-1621

PROJECT SCOPE

The purpose of this project is to define a supply-neutral optimized plan for the rapid build-out of the Fairbanks North Star Borough (FNSB) energy distribution infrastructure; one that delivers propane or natural gas by Liquefied Natural Gas (LNG) or pipeline, as affordably as possible, to the largest number of Borough residents and business properties. This cost estimate reports on the estimated cost of the construction of distribution and transmission lines to residential and commercial users within the vicinity of Fairbanks, Fort Wainwright, North Pole, and Eielson.

METHODOLOGY

At the time of estimate detailed design was not available. The pipeline construction estimate uses a factored approach for all aspects. All costs are based on recent projects with similar demands. Prices have been scaled to account for differences in size, location and constructability (e.g. presence of permafrost). Costs were split by construction phases, phase I areas of high (over 500 people/sq mile) and phase II in medium (100-500 people/sq mile) population densities.

Transmission line pipe, 10 and 8-inch steel pipe, estimation is based on lengths of pipe measured using GIS.

Distribution feeder line pipe, 6-inch plastic pipe, estimation is based on lengths of pipe measured using GIS.

Distribution line pipe, 2-inch plastic pipe, estimation is based on length of pipe in miles per square mile. The length of pipe per square mile is calculated based on the following

1. Independent concept pipe networks that are based on FNG expansion areas for high and medium density areas
2. Compare independent pipe network with FNG's identified expansion areas
3. Calculate average and standard deviation values to verify results, which indicate that using this approach could generate realistic estimate of pipe length.

HIGH Population Density			
FNG Expansion Area	**Length of Pipe (mi)**	**Area (sq mi)**	**Miles of Pipe per sq mi**
6	9.0	0.6	15.0
19	3.8	0.25	15.2
20	6.9	0.5	13.8
		Average:	14.7
		Std Dev:	0.8
		Use for Estimating:	15.0

MEDIUM Population Density			
FNG Expansion Area	**Length of Pipe (mi)**	**Area (sq mi)**	**Miles of Pipe per sq mi**
33	18.9	3.1	6.1
25	24.0	3.2	7.5
24	17.8	2.3	7.7
		Average:	7.1
		Std Dev:	0.9
		Use for Estimating:	7.0

Service line piping, 1-inch and 0.625-inch plastic pipe, estimation is based on the number of identified service connections within high and medium density areas and classified as residential or commercial multiplied by an assumed tie-in pipe length for high and medium areas.

Horizontal Directional Drill (HDD) is estimated for two river crossings with each crossing being 800 feet in length.

Pressure Regulating Stations, including Gate Stations and Regulator Stations, are estimated by connection points between transmission line and distribution feeder lines or industrial users.

Cathodic Protection is required for all steel pipe, estimation is based on length of steel pipe.

COST BASIS

The Project Estimator uses the project work breakdown structure, material take-offs, labor productivity rates, price data, other unit rates, and factors to build spreadsheets to calculate the TIC estimate.

The following summarizes the various rates this estimate uses to calculate costs for the estimate.

Construction costs:

Pipe diameter [in]	Installed Cost	Unit	Quantity High density	Quantity Medium density
10	$ 90	LF	168,494	0
8	$ 90	LF	16,149	0
6	$ 50	LF	277,035	348,820
2	$ 25	LF	2,311,922	2,607,980
1	$ 25	LF	15,375	26,000
0.625	$ 25	LF	837,000	782,500
HDD	$ 400	LF	1,600	0
Cathodic protection	$ 15,000	mile	35	0
Gate station	$ 1,250,000	each	9	0
Regulator station	$ 400,000	each	9	0
Pigging connection	$ 50,000	each	4	0

1. Bare steel pipe material priced at $2000/ton. High Frequency Induction (HFI) Welded material. Freight is included to Fairbanks.
2. FBE coating of steel pipe is estimated at $1.69/inch diameter, adjusted from Flowline Alaska quotation.
3. HDD costs assume 130 foot bank to bank length with 800 total length at each crossing, pilot hole with 1 reaming pass, four total crossings. Mobilization/demobilization is included in unit cost of $400/LF.
4. Cathodic protection is included for all steel pipe.
5. Gate stations are needed to house purchase meters for gas measurement and to reduce line pressures between the transmission line and a delivery line. Their cost is assumed to be $1,250,000 each.
6. Regulator stations are needed to reduce transmission line pressures to local distribution pressures (60psig). Their cost is estimated at $400,000 each.

Material costs:

Direct material costs		
Pipe diameter [in]	Pipe [$/LF]	Valves [$/Each]
10- steel	$ 53	$ 34,000
8- steel	$ 44	$ 20,000
6-plastic	$ 12	$ 13,300
2-plastic	$ 6	$ 6,200
1-plastic	$ 5	$ 500
0.625-plastic	$ 5	$ 500

1. Freight for pipe is included in the material cost
2. Pigging barrels are mobile 12-inch diameter, skid mounted and can be connected to 10 and 8-inch pipe. Unit cost of $300,000 for both a launcher and receiver.
3. Supplier Quality Surveillance (SQS) are tests to ensure quality materials are provided and used for the project. They are assessed at 2% of the material (valve and pipe) costs.
4. Procurement costs are assumed to be 4% of material costs.

Other costs:

1. Engineering is assumed to be 5% of pipeline construction cost.
2. Engineering for launcher/receive is assumed to be 30% of launcher/receiver construction cost.
3. Permitting based on current scope and region as compared to recent projects, estimated cost is $300,000 for phase I and $200,000 for phase II.

ALLOWANCES

A material allowance is included to account for items not identified by current level of design. These account for design modifications from the date of estimation to construction. Miscellaneous freight is applied to the material allowance. The costs below are part of the estimate allowances, and are included at the percentages shown.

Material allowances	
	Cost (relative to total cost of pipe & valves)
Materials- Design allowance	5%
Materials- Misc. Freight	2%

ASSUMPTIONS & DESCRIPTION OF WORK

The following are the assumptions that were applied to the pipeline, Launcher/Receiver, Gate and regulator stations, engineering and procurement estimates:

1. Adequate labor supply and life support (e.g., camp space, beds, transportation, etc.).
2. Contractor per diem is not included in the estimate.
3. Adequate funding available for this project.
4. All costs are based on 2012 dollars.
5. All materials and equipment will be on construction site as scheduled.
6. Estimated costs are based on factored costs from prior construction activities
7. Contractor markup and profit is included in factored price per linear foot for installation.
8. Weather delay costs are not included.
9. Engineering, procurement, and SQS based on percentages provided above.
10. Owner/operator will be responsible for procuring the major materials (valves, pipe).
11. Isolation valves required at each residence/commercial building and every 8 miles of transmission or distribution pipe.
12. Transmission lines shall be steel, distribution and service lines shall be plastic (PEX or HDPE).
13. Only 8 & 10 inch transmission lines shall be piggable.
14. 75 linear feet is assumed to be needed to tie houses/businesses to street level mainlines in areas of high population density. 100 linear feet is assumed to be needed in areas of medium population density. Areas of low population density have not been included.
15. For HDD it is assumed only for transmission and major distribution pipes crossing the Chena River

The following are the assumptions that were applied to the permitting and regulatory estimates:

1. NEPA report may not be required but is included in the anticipated permitting costs.
2. Field data is believed to exist in the project area. Therefore field study costs are not included in the estimate.

DESCRIPTION OF WORK

The following is the description of work tasks for the FNSB Natural gas study. Installation is planned for summer construction starting May 1 and ending September 30. Installation has been broken out into two phases of construction; phase I within 0-4 years centered in the high population density areas (over 500 people/sq mile), and phase II within 4-8 years centered in the medium population density areas (100-500 people/sq mile). Activities have been identified as being part of phase I, phase II construction, or both. Details on quantity can be found in estimate document.

- Transmission lines- installation of 10-inch steel transmission line from supply tie-in to Eielson and 8-inch line along Steese Highway terminating at the Johansen expressway all activities will occur in phase I and include:
  - Trenching and installation of 10” pipe
  - Trenching and installation of 8” pipe
  - Installation of isolation valves
  - Installation of gate stations for supply to industrial users (9)
  - HDD crossings of Chena River (2)
  - Connection to existing FNG lines as appropriate
  - Installation of connections for pigging (2)
  - Fabrication of mobile pig launcher and receiver (1 each)
  - Surface rehabilitation after construction (paving, seeding, etc)
- Installation of the primary feeder distribution lines (4 to 8-inch diameter) including:
  - Trenching and installation of linear feet of 6-inch pipe (phase I & II)
  - Installation of isolation valves (phase I & II)
  - Connection to existing FNG lines as appropriate (phase I)
  - Regulation stations for supply to domestic users (phase I)
  - HDD crossings of Chena River (phase I)
  - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)
- Installation of 2-inch diameter distribution lines along residential roads including:
  - Trenching and installation of 2-inch pipe (phase I & II)
  - Installation of isolation valves (phase I & II)
  - Connection to existing FNG lines as appropriate (phase I)
  - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)
- Installation of service lines to residential and commercial users including:
  - Trenching and installation of 1-inch pipe for commercial users (phase I & II)
  - Trenching and installation of 5/8-inch pipe for residential users (phase I & II)
  - Installation of isolation valves (phase I & II)
  - Surface rehabilitation after construction (paving, seeding, etc) (phase I & II)

UNKNOWN COSTS

The Unknown Costs (UC) 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 unknown costs cover field uncertainties, inadequacies in complete project scope definition, estimating methods, and estimating data. Unknown costs specifically excludes changes in project scope, and unforeseen major events such as earthquakes, prolonged labor strikes, failed HDD, weather delays, etc. The amount of UC is based on the AACE estimate class 4.

The UC level used for these estimates is +30%.

QUALITY ASSURANCE

The Baker estimate Quality Assurance lead, in consultation with the Baker Project Estimating Team members, will review 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**
Bill Olzack	QA	MBJ	3/30/12

REFERENCES & ATTACHMENTS

Many documents will be collected 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**
Figure 7 Proposed Pipeline Layout	1/24/2012
Figure 5 High, Medium, and Low Demand Areas	2/27/2012