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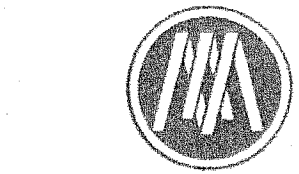

MUSE
STANCIL

DISCUSSION PAPER

PROSPECT FOR THE DEVELOPMENT OF A FAIRBANKS PETROCHEMICAL INDUSTRY

Prepared for

STATE OF ALASKA

June 2004

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INTRODUCTION

- The State of Alaska has retained Muse, Stancil & Co. (Muse) as a technical advisor on matters relating to the commercialization of Alaska North Slope natural gas and natural gas liquids (NGL) as it relates to the Alaska Gas Pipeline (AGP).

- As part of this advisory service, Muse was asked to undertake a high-level review of the prospects for the development of a petrochemical industry in Fairbanks using the NGL as feedstock.
  - The purpose of the high-level review is to help determine whether there is merit in pursuing this matter in more detail.

- In addressing this subject, Muse has focused on the commercial issues of petrochemical industry development, rather than the geopolitical issues.
  - Commercial issues encompass market fundamentals of supply, demand and pricing, technology, capital and operating costs, infrastructure, and logistics
  - Geopolitical issues include in-state industrial development and economic diversification.
    - State subsidies and guarantees can have significant influence
  - Muse has also not specifically addressed environmental impact issues, although it is assumed that new facilities could meet all EPA and other jurisdictional requirements.

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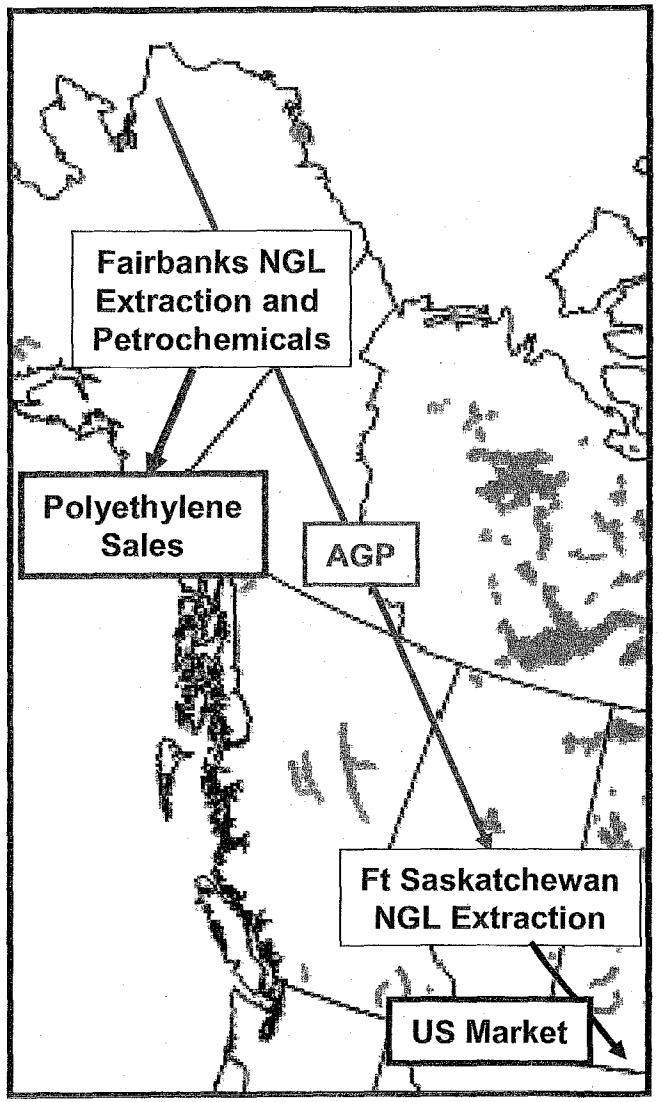
SUMMARY OF FINDINGS

- Based on a high-level review of the commercial issues, there appears to be insufficient support for the development of a Fairbanks petrochemical industry.
- **The development concept**
  - For purposes of this review, it is assumed that the project would be a world scale petrochemical complex, comprised of the following:
    - Fairbanks NGL extraction and fractionation facility
    - A 1.5 billion pound per year ethylene cracker utilizing ethane as its feedstock
    - Polyethylene plant producing plastic resin
    - Feedstock and product storage
    - Utility systems
    - Power generation
    - Rail shipment of resin to Whittier for export



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SUMMARY OF FINDINGS (CONTINUED)

- **Advantages of Fairbanks Petrochemical Development**
  - Availability of attractively priced feedstock (although requires extraction from AGP)
  - Waterborne access to California market
  - Synergy with other potential energy developments
    - Provides pipeline quality natural gas to Fairbanks
      - Could run gas pipeline to Anchorage (supplement Cook Inlet gas)
    - Possible cogeneration plant tied into regional power grid
      - Offset Cook Inlet gas decline and power generation

- **Disadvantages of Fairbanks Petrochemical Development**
  - Variability in gas composition over time
    - Non-optimal sizing and operation of Fairbanks extraction and fractionation plant
  - Inherent inefficiency of processing a large portion of the gas twice
    - First at Fairbanks, and then again in Alberta
  - Non-optimal sizing of AGP downstream of Fairbanks
  - Considerably higher capital cost than other locations
  - Higher fixed operating cost than other locations
  - Lack of supporting infrastructure
  - Lack of market for byproducts

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SUMMARY OF FINDINGS (CONTINUED)

- **Availability of Feedstock**
  - The volume of NGL in the AGP is more than sufficient to support a world scale ethylene cracker.
  - Access to the NGL at Fairbanks would require a large extraction and fractionation facility, with re-injection of most of the natural gas, and some of the NGL, back into the AGP.
  - This facility would change over time as the gas composition changes
  - Due to timing and reliability issues, the AGP and its end-of-pipe extraction and fractionation facilities would likely need to be sized for 100 percent of the gas and NGL volume, and be underutilized to the extent that volume is pulled out at Fairbanks

- **Feedstock Price Advantage**
  - NGL prices in Fairbanks would likely reflect Alberta netbacks (Alberta price less transportation)
  - This would give a Fairbanks location a competitive feedstock price advantage over petrochemical facilities operating in Alberta and the U.S. Gulf Coast (USGC)
  - The advantage may be partially offset
    - If the AGP owners want capital recovery on the unutilized pipeline capacity
    - By the cost of extraction and fractionation in Fairbanks

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SUMMARY OF FINDINGS (CONTINUED)

- **Infrastructure Supports Existing Petrochemical Centers**
  - Although there is some refining capacity just south of Fairbanks, this petrochemical facility would essentially be a new stand-alone industrial development
  - Only a handful of petrochemical centers exist in the U.S. and Canada
    - The largest by far is the USGC (contains 80 percent of U.S./Canada ethylene capacity)
      - Other centers include Alberta, Canada (12 percent), Sarnia, Canada (3 percent), U.S. Mid-west (3 percent) and U.S. East Coast (1 percent)
    - The Fairbanks facility would add 2 percent to the capacity
  - The existing centers provide supporting infrastructure
    - Feedstock supply systems in place offering flexibility and reliability of supply
    - Storage systems, often including salt dome caverns
    - Typically part of large integrated and complex refining and petrochemical operation
      - Shared cost of operations including utility systems and water treatment
    - Derivative plants utilize products and byproducts
    - Large local pool of skilled operating labor, maintenance services and equipment suppliers
    - Transportation systems
  - These elements have supported continued growth of the industry within these centers
    - Conversely, they represent a barrier to new remote green-field locations

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SUMMARY OF FINDINGS (CONTINUED)

- **Higher Capital Costs**
  - The capital cost for a Fairbanks location is likely to be 35 percent higher than that of the USGC, and 25 percent higher than that of Alberta
  - Additional capital also required for new infrastructure including the extraction and fractionation facilities, utility systems, storage, warehousing, transportation

- **Higher Fixed Operating Costs**
  - Labor and maintenance costs are higher than competing locations
  - Operator wages are about 40 percent higher in Alaska than on the USGC
    - In addition, there may be additional burden for subsidized housing/cost of living
  - Maintenance costs likely to be 35 percent higher than USGC (tied to a percentage of the capital cost)

- **Polyethylene Markets**
  - The polyethylene resin would be shipped out of Whittier, Alaska
    - Likely market would be U.S. West Coast
    - Competition with resins from Southeast Asia, and rail supply from USGC

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SUMMARY OF FINDINGS (CONTINUED)

- **Preliminary Economics**
  - High level analysis indicates that the production of ethylene in Fairbanks is economically less attractive than in either Alberta or the USGC
  - Advantages of:
    - Lower feedstock price (ethane)
    - Lower variable operating cost advantage, driven mainly by lower gas price
  - More than offset by:
    - Higher fixed operating cost due to higher labor and maintenance costs
    - Lower product value due to downgrading byproducts to fuel
  - Significantly higher capital costs also a disincentive to invest
  - Using recent USGC historical benchmarks, and assuming a Fairbanks location could achieve the same operating cash margin, due to the higher investment cost, a Fairbanks ethylene plant would generate a much less attractive rate of return
    - Returns shown below are expressed as capital recovery factor (CRF)

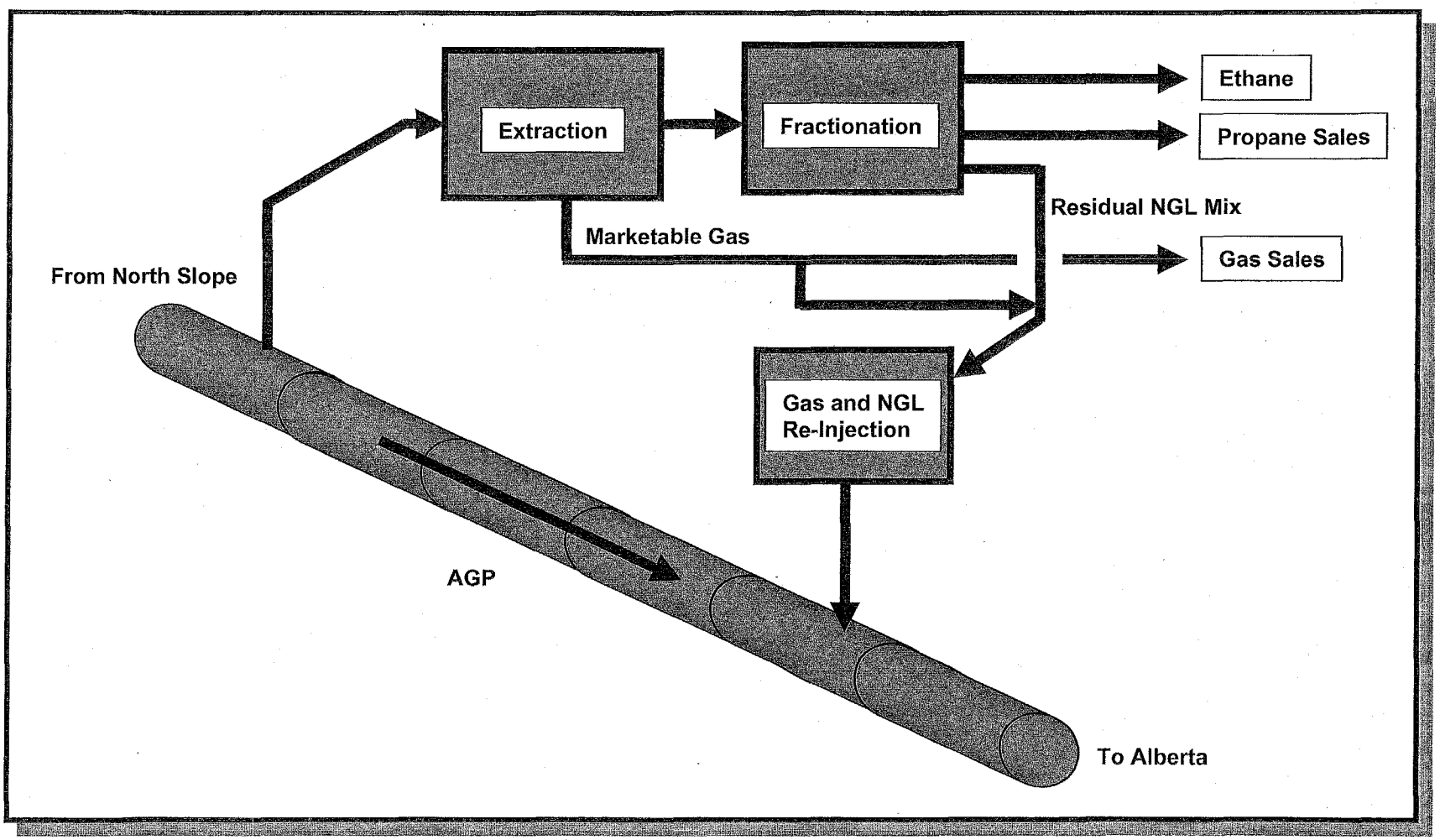
Return on Capital

	Annual Revenue	CRF	
	$mm	USGC	Fairbanks
2004 YTD	158.5	11.3%	7.1%
2003 avg.	125.0	8.9%	5.6%
2002 avg.	127.0	9.1%	5.7%
2001 avg.	153.6	11.0%	6.8%

SGI_001403

FAIRBANKS OFF-TAKES

- Extraction and fractionation to recover ethane as cracker feedstock, with propane and natural gas to serve local market
- Surplus gas and gas liquids are re-injected into AGP



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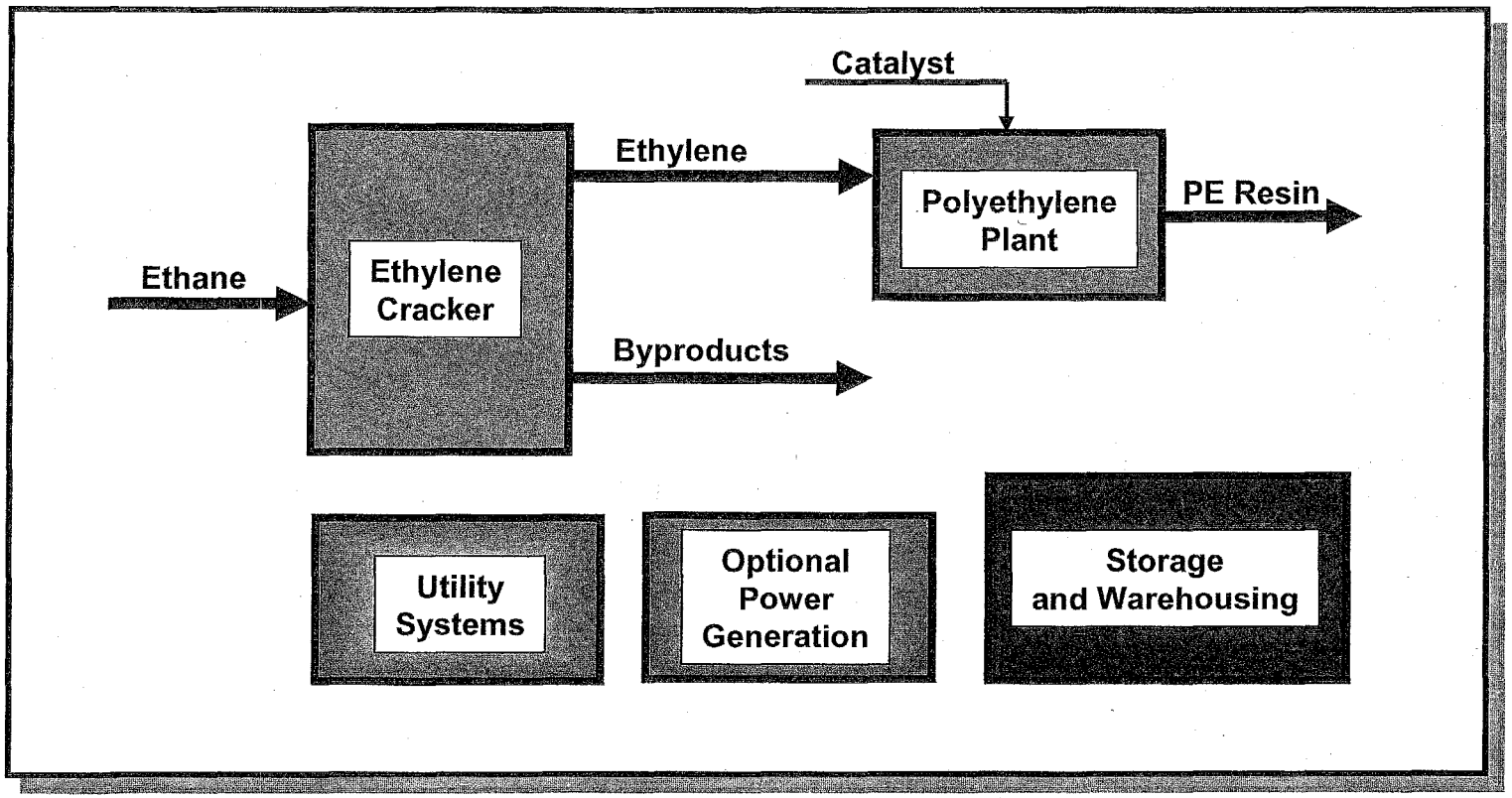
FAIRBANKS PETROCHEMICAL COMPLEX

- Cracker produces ethylene and byproducts
  - In an isolated facility such as this, byproducts likely used for fuel
- Difficult to export ethylene as a product
  - Polyethylene plant polymerizes to plastic resin for export



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MATERIAL BALANCE

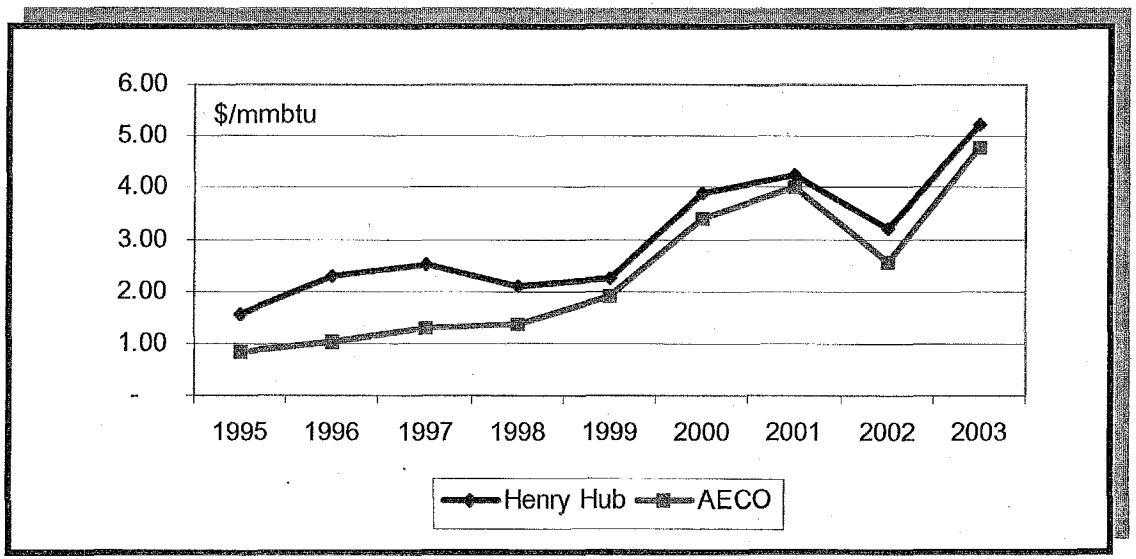
- The table below gives an approximate material balance based on the production of 1.5 billion pounds per year of ethylene
  - In addition, Fairbanks is supplied with 1.0 thousand barrels per day (MBPD) of propane, and 72.8 megawatt (MW) of power
    - The power assumes 100 MW plant, net of petrochemical plant demand
- Two observations are made:
  - A large volume of gas is processed to remove the required volume of ethane
    - Most of the processed gas is re-injected back into the AGP
  - The amount of gas processed increases over time due to compositional changes

	2015	2020	2025	2030	2035	2040
Net Gas production at North Slope, MM SCFD	4,297.0	4,296.0	4,296.0	4,293.0	4,294.0	3,725.0
Gas processed at the Fairbanks facility, MM SCFD	1,070.1	1,070.1	1,108.3	1,241.3	1,349.2	1,379.2
Ethane consumed to produce ethylene, BPD	38,765	38,765	38,765	38,765	38,765	38,765
Propane sales, BPD	1,000	1,000	1,000	1,000	1,000	1,000
Gas consumption for power generation, MM SCFD	14.7	14.7	14.7	14.7	14.7	14.7
Net gas and liquids to be re-injected, MM SCFD	989.9	988.8	1,028.5	1,156.6	1,261.1	1,291.8
Power sales, MW	72.8	72.8	72.8	72.8	72.8	72.8

SGI_001406

PRICING – NATURAL GAS

- The chart below compares the prices of natural gas on the USGC and in Canada
  - Henry Hub – USGC reference point
  - AECO – Alberta, Canada reference point
- With the increase in Canadian gas pipeline capacity (both new pipe and expansion of existing) into the U.S. Mid-West, and the increase in demand, the gas price differential has narrowed significantly



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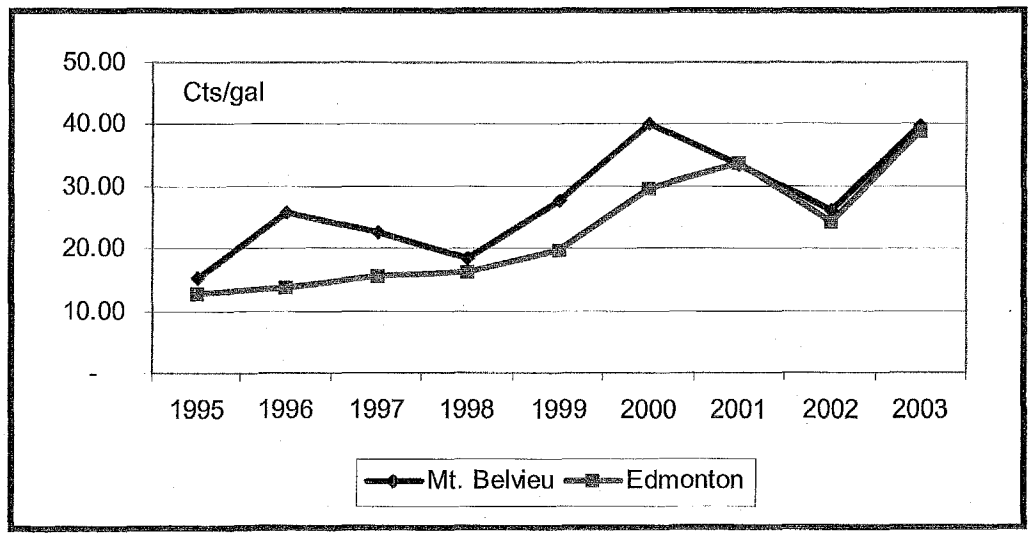
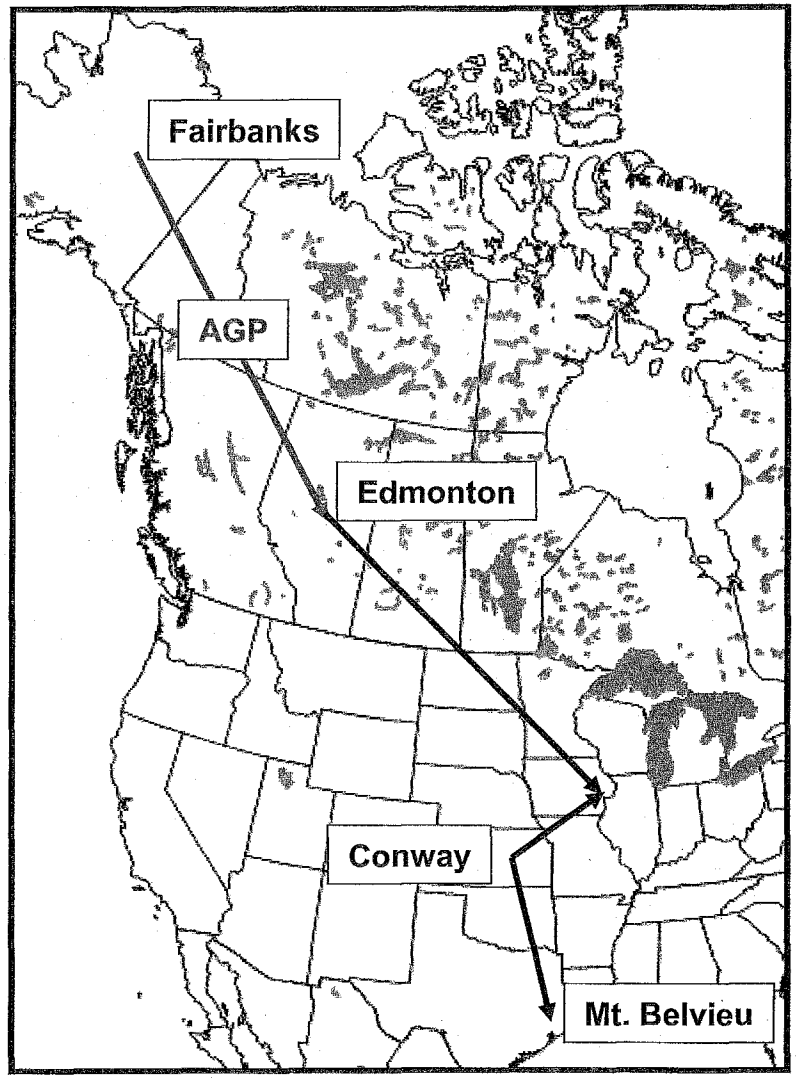
PRICING - ETHANE

- Historical Alberta and USGC ethane prices show the feedstock price advantage for an Alberta location
  - Much of the Edmonton, Alberta feedstock price advantage has eroded at the higher gas prices and as the Alberta gas price has trended toward the Henry Hub price
- Fairbanks would see a price advantage over Alberta
  - Possibly equal to the variable cost of AGP
  - The fixed cost of AGP would still be incurred whether or not ethane is extracted at Fairbanks





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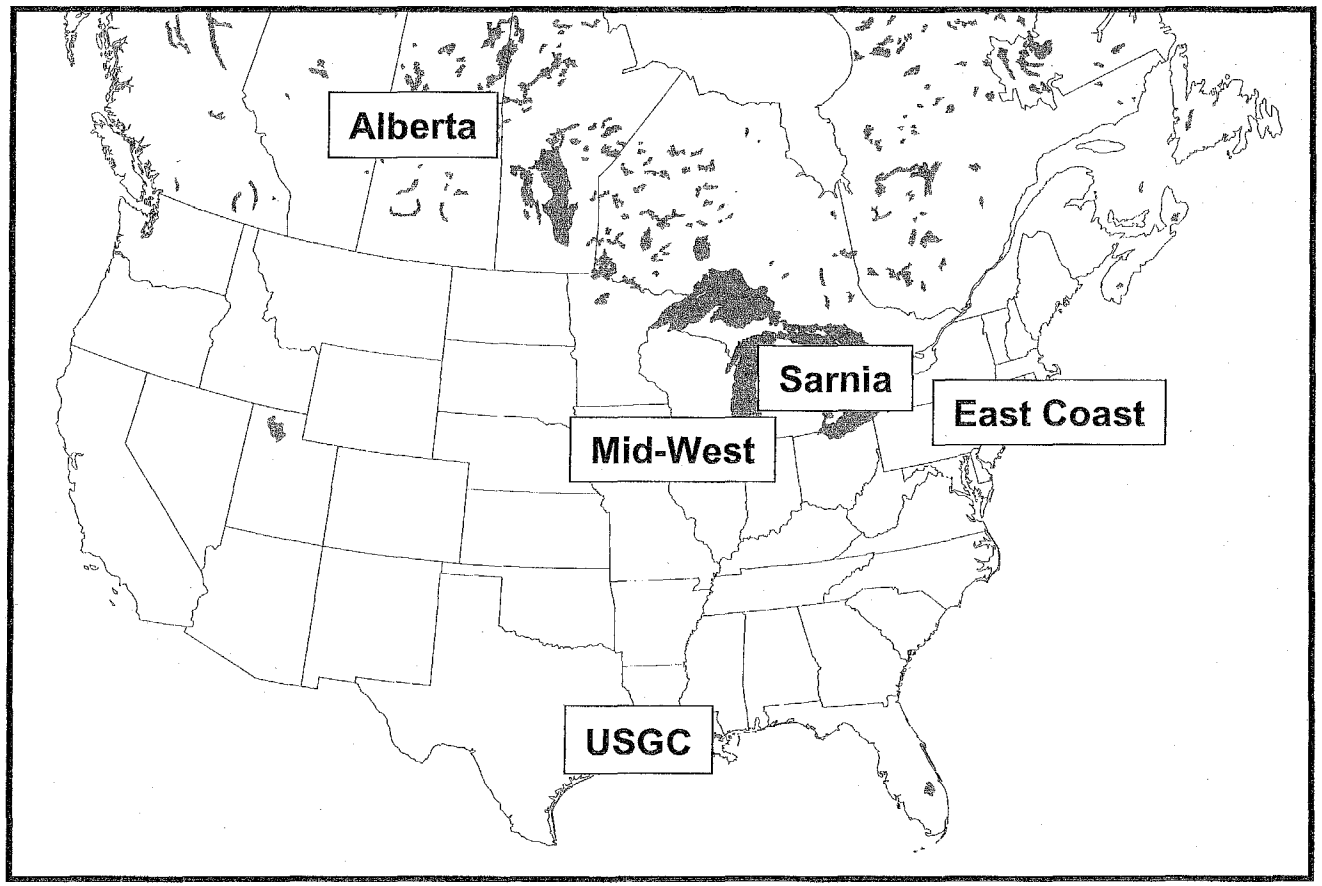
U.S./Canada Ethylene Production Centers

- Five geographic centers encompass almost all of the U.S. and Canada ethylene capacity
  - The largest center by far is the USGC (contains 80 percent of U.S./Canada ethylene capacity)
  - Other centers include Alberta, Canada (12 percent), Sarnia, Canada (3 percent), U.S. Mid-west (3 percent) and U.S. East Coast (1 percent)



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USGC Ethylene Capacity

Company	Location	St.	Capacity (tpy)	Feedstock Mixture, %					
				Ethane	Propane	Butane	Naphtha	Gas Oil	Other
USGC									
Dow Chemical Co. (Union Carbide)	Plaquemine (LHC 2)	LA	520,000	80	20				
Dow Chemical Co. (Union Carbide)	Plaquemine (LHC 3)	LA	710,000	20	30		50		
Dow Chemical Co. (Union Carbide)	Taft 1	LA	590,000	25	25		50		
Dow Chemical Co. (Union Carbide)	Taft 2	LA	410,000	25	25		50		
Equistar Chemicals LP	Lake Charles	LA	400,000	80	20				
ExxonMobil Chemical Co.	Baton Rouge	LA	1,000,000	60	20	20			
Sasol North America Inc.	Westlake	LA	453,000	100					
Shell Chemicals Ltd.	Norco	LA	600,000	45	5	5	45		
Shell Chemicals Ltd.	Norco	LA	900,000	5			35	60	
Westlake Petrochemicals Corp.	Sulphur	LA	590,000	65	35				
Westlake Petrochemicals Corp.	Sulphur	LA	436,000	100					
Williams Energy Services	Geismar	LA	612,000	90	10				
BASF Fina Petrochemicals	Port Arthur	TX	920,000				100		
BP PLC	Chocolate Bayou	TX	1,451,000	50	35		15		
Chevron Phillip Chemical Co.	Cedar Bayou	TX	794,000	30	20	25	25		
Chevron Phillip Chemical Co.	Port Arthur	TX	794,000	70	25	5			
Chevron Phillip Chemical Co.	Sweeny	TX	318,000	100					
Chevron Phillip Chemical Co.	Sweeny	TX	680,000	75	25				
Chevron Phillip Chemical Co.	Sweeny	TX	907,000	38	37	25			
Dow Chemical Co. (Union Carbide)	Freeport (LHC 7)	TX	590,000	50	50				
Dow Chemical Co. (Union Carbide)	Freeport (LHC 8)	TX	950,000	10	70		20		
DuPont	Orange	TX	590,000	100					
Eastman Chemical Co.	Longview	TX	684,000	25	67	7	1		
Equistar Chemicals LP	Channelview	TX	875,000	5			95		
Equistar Chemicals LP	Channelview	TX	875,000	5			95		
Equistar Chemicals LP	Chocolate Bayou	TX	544,000				100		
Equistar Chemicals LP	Corpus Christi	TX	771,000	10	30		60		
Equistar Chemicals LP	LaPorte	TX	789,000	60	20		20		
ExxonMobil Chemical Co.	Baytown	TX	2,150,000	60	20	20			
ExxonMobil Chemical Co.	Beaumont	TX	816,000	50	15	35			
ExxonMobil Chemical Co.	Houston	TX	356,000	90	10				
Formosa Plastics Corp. USA	Point Comfort	TX	714,000	35	35		30		
Formosa Plastics Corp. USA	Point Comfort	TX	816,000	35	35		30		
Huntsman Corp.	Odessa	TX	230,000						100
Huntsman Corp.	Port Arthur	TX	635,000				60		40
Javelina Co.	Corpus Christi	TX	151,000						100
Shell Chemicals Ltd.	Deer Park	TX	1,000,000	15		5	50	30	
Total Capacity, tpy			**26,621,000**	**11,051,360**	**5,446,320**	**1,508,430**	**7,139,890**	**840,000**	**635,000**
Feedstock, bpd				**637,346**	**416,724**	**111,420**	**478,166**	**63,927**	**47,781**

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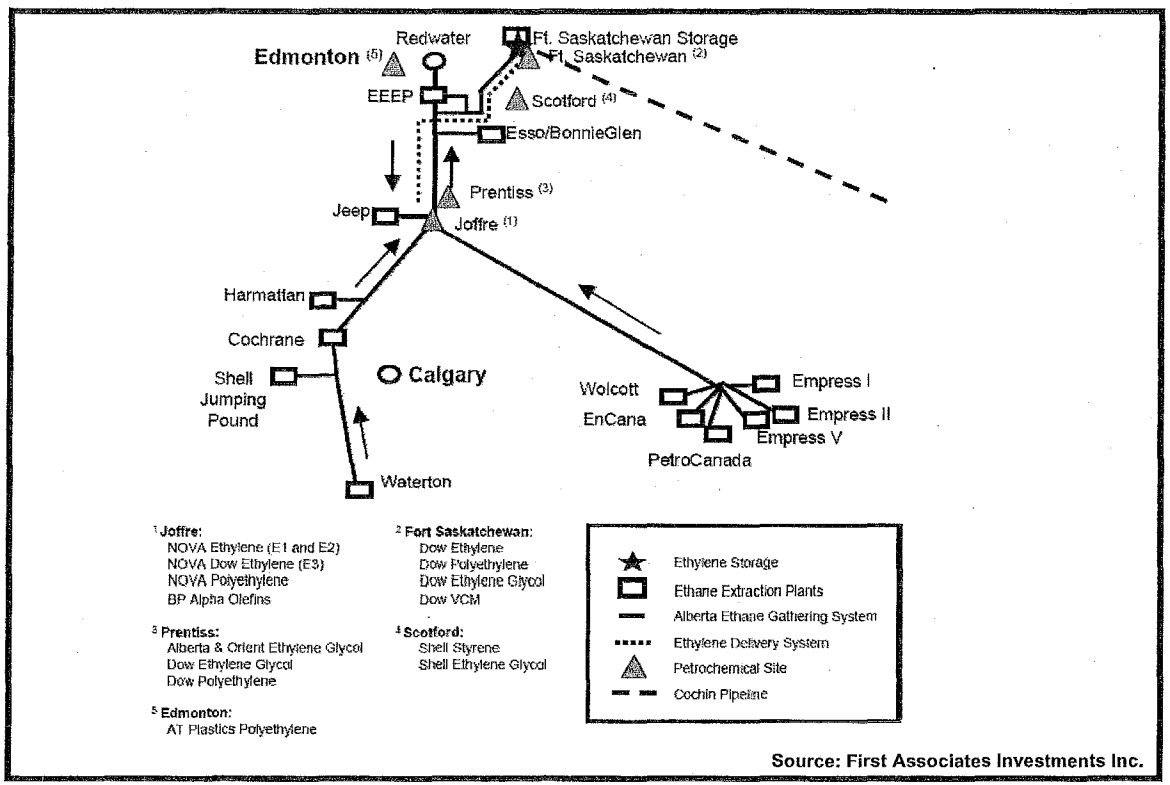
ALBERTA ETHYLENE CAPACITY

- The Alberta, Canada ethylene business is based on ethane feedstock
  - Ethane pipeline system is an integrated part of Alberta's petrochemical industry

Company	Location	Prov.	Capacity (tpy)	Feedstock Mixture, % Ethane	Propane	Butane	Naphtha	Gas Oil	Other
ALBERTA									
Dow Chemical Co	Ft. Saskatchewan	AB	1,275,000	100					
Nova Chemicals Corp	Joffre, E1	AB	726,000	100					
Nova Chemicals Corp	Joffre, E2	AB	816,000	100					
Nova Chemicals Corp	Joffre, E3	AB	1,270,000	100					
Total Capacity, tpy			**4,087,000**	**4,087,000**	-	-	-	-	-
Feedstock, bpd				**235,702**	-	-	-	-	-



Source: First Associates Investments Inc.

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OTHER U.S./CANADA ETHYLENE CAPACITY

- A handful of companies operate ethylene plants outside of the USGC and Alberta

Company	Location	Prov.	Capacity (tpy)	Feedstock Mixture, % Ethane	Propane	Butane	Naphtha	Gas Oil	Other
SARNIA									
Imperial Oil Products & Chemicals	Sarnia	ON	270,000	80	15				5
Nova Chemicals Corp	Corunna	ON	725,000	0	10	25	50	15	
Total Capacity, tpy			**995,000**	**216,000**	**113,000**	**181,250**	**362,500**	**108,750**	**13,500**
Feedstock, bpd				**12,457**	**8,646**	**13,388**	**24,277**	**8,276**	**1,016**

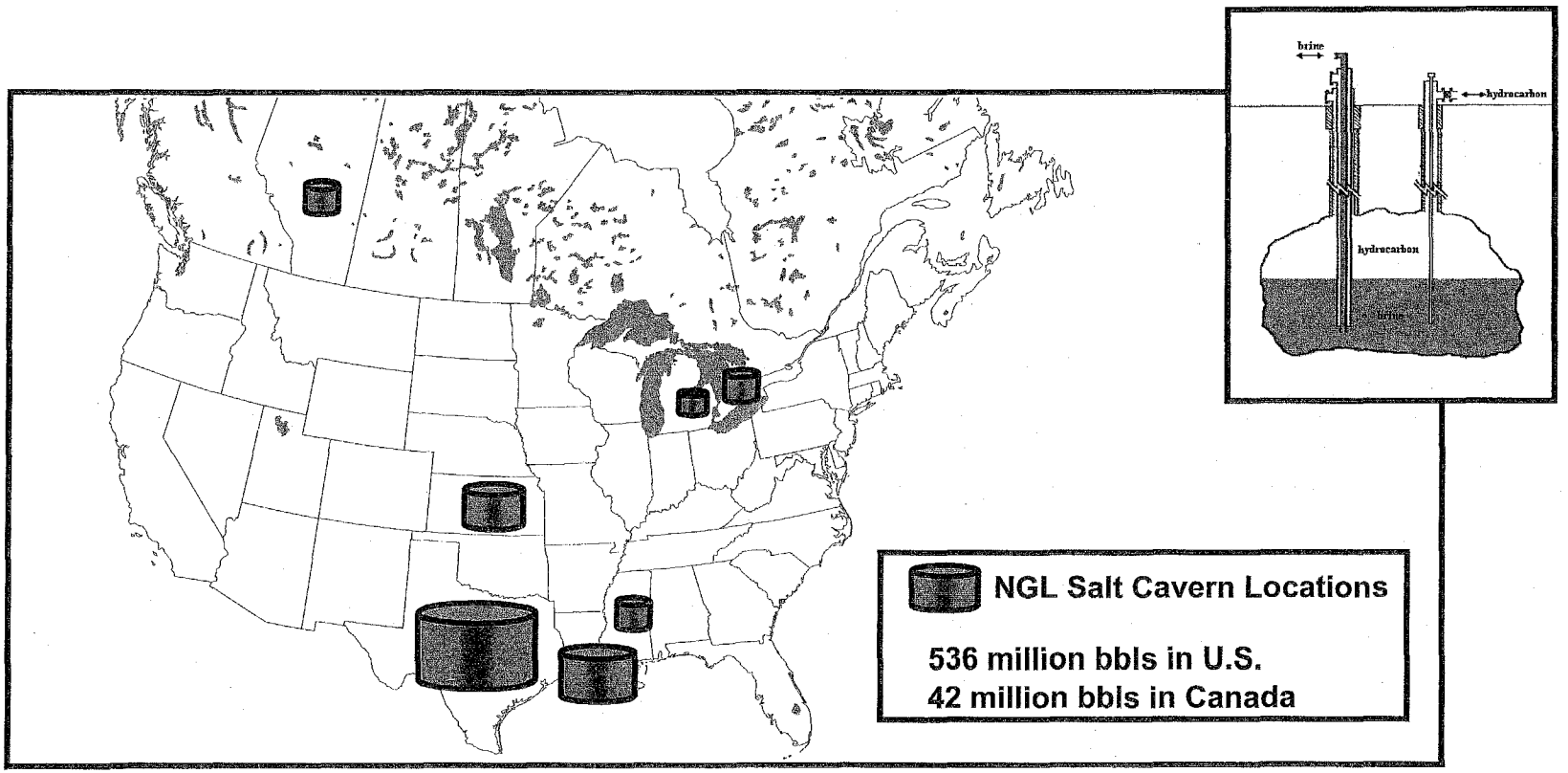
Company	Location	St.	Capacity (tpy)	Feedstock Mixture, % Ethane	Propane	Butane	Naphtha	Gas Oil	Other
MIDWEST									
Equistar Chemicals LP	Clinton	IA	476,000	80	20				
Equistar Chemicals LP	Morris	IL	550,000	80	20				
Total Capacity, tpy			**1,026,000**	**820,800**	**205,200**	-	-	-	-
Feedstock, bpd				**47,337**	**15,701**	-	-	-	-

Company	Location	St.	Capacity (tpy)	Feedstock Mixture, % Ethane	Propane	Butane	Naphtha	Gas Oil	Other
PADD 1									
Westlake Petrochemicals Corp.	Calvert City	KY	181,000		100				
Sunoco, Inc.	Marcus Hook	PA	225,000	50	50				
Total Capacity, tpy			**406,000**	**112,500**	**293,500**	-	-	-	-
Feedstock, bpd				**6,488**	**22,457**	-	-	-	-

SGI_001412

SALT CAVERN STORAGE OF NGL

- Salt caverns comprise a large percentage of the North American NGL storage capacity
  - In Texas, 58 percent of the NGL is stored in salt caverns (of which 36 percent is at Mont Belvieu)
- Salt cavern locales often become NGL market hubs and support petrochemical centers
  - The establishment of petrochemicals centers have resulted not only from availability of NGL feedstock, but also the availability of salt for the manufacture of chlor alkali



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CAPITAL COST

- Nominally, a world scale ethylene/polyethylene plant (1.5 billion pound per year) on the USGC would cost about $1.9 billion
- A Fairbanks facility, including the extraction and fractionation plant, and accounting for location cost differences, would be about $2.9 billion, a significant increase
  - Location factor, which accounts for the difference in the cost of construction in Alaska versus the USGC, is estimated at 1.35
    - Location differences arise from higher labor rates, need for construction camps to house workers, higher delivered material costs, need for equipment winterization and lower productivity due to weather
  - In addition, the Fairbanks facility would bear additional costs associated with storage and other infrastructure, not required to the same extent at a USGC location

	Feed or Production Rate	*USGC Cost, $ MM*	*Fairbanks Location Factor*	*Cost in Fairbanks, $ MM*
Gas plant, MM SCFD	1,070	258	1.35	349
Ethylene cracker, MT/yr.	680,581	1,404	1.35	1,896
Polyethylene plant, MT/yr.	680,581	493	1.35	666
Total		**2,156**		**2,910**

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FIXED OPERATING COSTS

- The two main components of the fixed operating cost of a plant are labor and maintenance
  - Both are higher in Fairbanks than competing locations
  - Operator wages are about 40 percent higher in Alaska than on the USGC
    - In addition, there may be a requirement for additional burden/incentives for example, subsidized housing/cost of living adjustments
  - Maintenance costs can be benchmarked as a percentage of capital replacement cost
    - This would suggest that maintenance cost would likely to be 35 percent higher than USGC

STATE OCCUPATIONAL EMPLOYMENT AND WAGE ESTIMATES

		2003 Mean (Hourly)
Alaska	Petroleum Pump System Operators, Refinery Operators, and Gaugers	$32.34
Houston, Texas	Petroleum Pump System Operators, Refinery Operators, and Gaugers	$22.89
	Chemical Equipment Operators and Tenders	$22.83

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ECONOMICS

- The top table summarizes USGC ethylene plant margins through April 2004, and for the last three years
  - Muse calculates these figures routinely for publication in the *Oil & Gas Journal*
- The lower chart calculates a simple return on capital
  - CRF is cash margin divided by capital cost, expressed as a percentage
  - For the USGC, the capital cost is $1.4 billion for on a 1.5 billion pound per year plant
    - Returns range from 9 percent to 11 percent
  - For Fairbanks, the capital cost is $2.2 billion after allowance for the extraction plant and location cost differences
    - Returns range from 6 percent to 7 percent
    - This assumes that the Fairbanks cash margin would be the same as the USGC
      - It might actually be lower, as higher labor and maintenance costs more than offset any feedstock price advantage
      - This would result in returns lower than shown

Muse, Stancil & Co.
Ethylene Margins
(¢/lb ethylene)

April 2004	**Ethane Feedstock**
Product revenues	38.28
Feedstock costs	-17.23
Gross margin	21.05
Fixed costs	-5.38
Variable costs	-4.21
Cash operating margin	**11.46**
March 2004	12.00
2004 YTD avg.	10.57
2003 avg.	8.33
2002 avg.	8.47
2001 avg.	10.24

Return on Capital

	Annual Revenue	***CRF***	
	$mm	***USGC***	***Fairbanks***
2004 YTD	158.5	11.3%	7.1%
2003 avg.	125.0	8.9%	5.6%
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2001 avg.	153.6	11.0%	6.8%

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