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Date: August 13, 2004

Mr. Antony Scott
Department of Natural Resources
Division of Oil and Gas
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Anchorage, Alaska 99501 - 3560
Email: Antony_Scott@dnr.state.ak.us

Reference: 16" Gas Pipeline System – Fairbanks to Cook Inlet

Dear Antony:

Paragon Engineering Services Inc. (Paragon) has performed a brief engineering review and has updated the cost estimate contained in the Stone and Webster Engineering Corporation (Denver, Colorado J.O. No. 17979.01) document entitled "Estimated Costs and Environmental Impacts of A Natural Gas Pipeline System Linking Fairbanks With Cook Inlet Area," dated January 1989, which was prepared for the Alaska Power Authority.

The following provides Paragon's updated cost estimate and summarizes our findings and recommendations, related to the analysis and review of the above referenced document.

Executive Summary

Paragon has attached two up dated cost summary charts, each of which updates the original 1988 Stone and Webster 16" pipeline system's cost summary exhibit. The first chart updates the original cost estimate utilizing the original 5% contingency factor and results in an estimated $244,528,065 total installed cost and the second chart updates the original cost estimate utilizing Paragon's recommended 10% contingency factor and results in a $254,960,008 total installed cost.

The 16", 20" and 24" detailed pipeline system cost estimates are also attached for both the 5% and 10% contingency cases. Table 1 summarizes the estimated costs for all of the above referenced pipeline systems, rounded off to the nearest million dollars.

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Table 1 – Estimated Pipeline Costs (July 2004)

Pipeline Nominal Size (Inches)	Total Installed Cost With 5% Contingency Factor ($1,000,000/s)	Total Installed Cost With 10% Contingency Factor ($1,000,000/s)
16	245	255
20	300	313
24	375	391

Table 2 displays the various pipeline sizes and their corresponding approximate capacities (flow rates), determined by a very simple hydraulic model, utilizing the universal gas flow equation and it is based on the original inlet and outlet process conditions.

Table 2 – Approximate Capacity (Flow Rate)

Pipeline Nominal Size (Inches)	Capacity (MMSCFD)
16	61.3
16 (with 1,000 hp of inlet compression)	88.3
20	102.8
24	164.6

Evaluation Criteria and Methodology

Paragon initiated the engineering review in July 2004 and commenced by reading the original January 1989 Stone and Webster document in its entirety. Particular attention was focused on the project's original design basis, the assumptions and the related 1988 cost estimate.

Paragon updated the original Stone and Webster 1989 project cost table, contained in section 1.5 Project Costs, for two different contingency factor cases, i.e. for the original 5% contingency factor case and PES' recommended 10% contingency factor case.

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The Stone and Webster 16" pipeline system consisted of the following major components:

- One (1), 16", API 5L - X60, triple random length (TRL), electric resistance welded (ERW), 298.7 mile long total length pipeline system rated for 61.3 MMSCFD. The engineering design criteria is 1440 PSIG MAOP, 1,000 PSIG upstream operating pressure, 685 PSIG downstream operating pressure to the inlet of the check meter and pressure regulating station, 550 PSIG meter station outlet pressure (Fairbanks city gate). The pipeline system is chiefly composed of approximately 63 miles of class one, 0.281" nominal wall thickness; approximately 211 miles of class two, 0.344" wall thickness; and approximately 24 miles of class three, 0.406" wall thickness pipe.
- One (1), upstream (Beluga tie-in) and custody transfer meter station rated for 61.3 MMSCFD, 1,440 PSIG MAOP and 1,000 PSIG normal operating pressure.
- One (1) downstream (Fairbanks) check meter and pressure regulating station rated for 61.3 MMSCFD, 1,440 PSIG MAOP and operating at a 685 PSIG inlet pressure and a 550 PSIG discharge pressure.
- One (1) mercaptan odorization system.
- Four (4) 20" pig launchers, to launch 16" pigs.
- Four (4) 20" pig receivers, to receive 16" pigs.
- Twenty-two (22) main line valve stations (four (4) complete with automated line break "rate of decline" pneumatic valve operators).
- 125 to 144 "open cut" (trenched) river and stream crossings.
- Nine (9) railroad crossings.
- Three (3) George Parks Highway crossings.
- Two (2) aerial crossings.
- Approximately 36.8 miles of designated wetlands (slough areas).
- Four (4) construction spreads (3 summer and 1 winter).
- Gas distribution system, including facilities for approximately 12,000 residential customers, commercial power plants (Fairbanks and the University of Alaska) and other non-military consumers. Note that the 16" base case excludes supplying fuel gas to the three potential military power plants.
- Optional - the addition of an inlet gas compressor station rated for 88.3 MMSCFD, 1,440 PSIG MAOP, 1,000 PSIG normal operating inlet pressure, 1,260 PSIG normal discharge pressure, approximately 1,000 hp, (Note, the compressor station is required to increase the 16" pipeline's throughput from 61.3 MMSCFD to 88.3 MMSCFD, which is required if the three military power plants (Fort Wainwright, Eielson, and Clear) are connected to the natural gas distribution system.

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The 1988-1989 Stone and Webster cost estimate's assumptions are briefly summarized as follows:

- A 5% contingency factor was utilized.
- The owner's costs were assumed to be 2% of the total installed cost (TIC).
- The engineering and design costs were assumed to be 3.5% of the total installed cost (TIC).
- The material inspection cost was assumed to be 0.5% of the total installed cost (TIC).
- The transmission line operation and maintenance cost was assumed to be 1% of the total installed cost (TIC).
- The cost estimate utilized labor and equipment rates (Ford Bacon) from the 1988 era, and were obtained from the "Alaska Laborers' and Mechanics' minimum Rates of Pay" and the "U.S. Army Corps of Engineers' Construction Equipment Ownership and Operating Expense Schedule."
- The original estimate's overall accuracy level was not indicated.

Paragon utilized the "Project Costs" table found in the original 1989 Stone and Webster document, section 1.5, page 1-4, and added new columns to the summary to reflect the current estimated costs. The original Stone and Webster costs exhibited in the table were factored to arrive at the current estimated costs. The factors utilized to multiply the numbers in the columns are shown directly below the respective columns.

The following methodology was used in determining the total installed cost of the above 16" referenced pipeline system and appurtenances. Paragon did not estimate the cost of each individual pipeline spread (as done by Stone and Webster), instead estimating the total cost of the entire 298.7 mile long pipeline system as a whole. The same basic assumptions were utilized from the original 1988 Stone and Webster pipeline cost estimate, except in two areas. Paragon added a $2,000,000 additional cost, for an environmental impact statement (EIS), which is currently deemed to be required. Paragon also assumed that the majority of the anadromous rivers and stream crossings would be horizontal directionally drilled (HDD) crossings, rather than being constructed by the original open cut and flume method (with the anticipated potential permit and sedimentation issue problems in anadromous streams). Paragon included $30,000,000 in the estimate HDD the majority of the river and stream crossings.

In order to determine the appropriate multiplication factors that should be applied to the "design, inspection and materials" column and the "construction" column of the original "Project Costs" table, Paragon utilized its proprietary cost estimating system to generate a July 2004 "conceptual quality" (+/- 35% accuracy cost estimate) for the entire 16" pipeline

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system and its appurtenances. Since the pipe material component cost is a very significant cost component in any pipeline system's overall cost, Paragon obtained, and utilized, current July 2004 estimated line pipe pricing from a pipe mill (for bare line pipe costs, pipe fusion bonded epoxy (FBE) coating costs and associated railroad transportation costs) to further refine and improve the overall cost estimates accuracy.

As part of the analysis, Paragon obtained and briefly reviewed the current labor and equipment "Ford Bacon" rates from the "Alaska Laborers' and Mechanics' minimum Rates of Pay" effective April 1, 2004 and the "U.S. Army Corps of Engineers' Construction Equipment Ownership and Operating Expense Schedule Region IX," dated July 2003 and briefly "spot checked" some current rates versus the original 1988 estimate's rates.

The proprietary program was again used to determine what multiplication factors should be applied to the original Stone and Webster 1988 cost estimate's "design material and Inspection" column and the "construction" column, of the original "1.5 Project Costs" exhibit. The factor for the "design, inspection and materials" column was determined by adding current material cost and the engineering and construction management costs (total indirect costs), times the contingency multiplication factor, divided by the 1988 cost for the same item. The "construction" factor was determined by adding Paragon's current material cost and the engineering and construction management costs (total indirect costs), times the contingency multiplication factor, subtracted from the overall total installed cost, divided by the 1988 construction cost. Paragon also determined the overall project multiplication factor that should be applied to the project's total estimated cost, by dividing the current 2004 total installed cost by the 1988 total installed cost.

In general, the "design, equipment and inspection" costs have increased by a 1.95 multiplier, primarily directly attributable to the significant increase in steel prices. The cost of steel is currently very volatile. Recently the price of steel has risen from approximately the $500 to $600 per ton range, to as high as $1,100 per ton, plus an additional $175 per ton surcharge, equaling a total of $1,275 per ton cost – this is approximately a 96% cost increase. Paragon obtained the current estimated cost of pipe, pipe coating and rail transportation form ACIPCO (a U.S.A. pipe mill) to improve the accuracy of the cost estimate. The quick spot labor rate comparison indicated that Alaska's labor rates have generally declined by approximately 5.5% resulting in a 0.94 factor. The project's total installed cost (TIC) has increased by approximately 28.7% resulting in a 1.29 factor. Paragon utilized the overall 1.29 multiplication factor to update the original optional compressor station's cost estimate and the gas distribution system's cost estimate.

In order to quickly confirm the current estimated cost of a 1,000 hp gas compressor station, Paragon obtained the current equipment pricing of a Solar Saturn 20/C160 compressor

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unit ($1.3MM each), ex-works, having an aero-derivative turbine engine driven centrifugal gas compressor (a major compressor station equipment cost) in order to evaluate a the optional compressor station's cost. Paragon also obtained the historical total installed costs of recently constructed similar compressor stations. The factored compressor station's estimated cost is within the current range of actual total installed costs for similar facilities.

Recommendations & Considerations

Paragon offers the following recommendations and thoughts for information and consideration:

- The price of steel is currently very volatile, and according to the pipe mills, this situation can be anticipated to continue into the future, especially when considering such global issues as the rebuilding of Iraq, with the potential for material and equipment shortages, and the demands of other developing third world requirements on the world wide manufacturing and construction infrastructure. As an example of current market conditions, some steel mills have only provided quotations that are valid for a 7-day time period, in lieu of the usual 30 days.
- Paragon obtained and utilized the current July 2004 estimated cost of pipe, pipe coating, and rail transport form ACIPCO a U.S.A pipe mill. In the recent past, ACIPCO has provided Paragon with the best pricing of the numerous mills contacted. However, it may be a worthwhile exercise to solicit additional estimated pricing from additional domestic and international pipe mills.
- The pipeline's material designation is currently ALP 5L – X60 having a 60,000 psi specified minimum yield strength, which could be changed to a higher yield strength material, such as API 5L – X80 PSL 2 having a 80,000 psi specified minimum yield strength, which will reduce: the pipeline's wall thickness, the tons of steel required, the cost of the pipeline pipe, and the transportation costs, all of which are significant cost elements in the pipeline system's total cost.
- The 1988 cost estimate's 5% contingency factor is deemed to be somewhat low for a cost estimate with this of this level of accuracy (considering the state of the engineering and design work in 1988). In practice, a 5% contingency factor is typically only applied if the engineering and design work has been completed, and if all of cost elements are firmly established and supported with quotations and the quantities of materials is firmly established. Paragon is of the opinion that a 10% contingency factor would be more typical and appropriate for cost estimating purposes.
- The previous 3.5% factored engineering and design cost is deemed to be a slightly overly optimistic estimate of the actual anticipated engineering and design work that would typically be required. The complete engineering and design work would

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normally entail the preparation of the following: a construction bid package, equipment specifications, construction specifications, equipment data sheets, instrumentation data sheets, construction drawings and bills of materials, approved vendor and contractor lists, requests for equipment quotations, bid analyses with recommendations, purchase order placement, contract placement, environmental assistance, route survey, construction survey, as built survey, right of way and damages, traffic management, construction management, inspection, permitting, startup and operating assistance, and "certified as built drawings" are all required, as well as probable assistance with the Federal Energy Regulatory Commission (FERC) filing, and assistance with the legal aspects of the FERC filing. The original engineering and design estimated cost did not mention the funding of an environmental impact statement (EIS) or the required compensation to the State of Alaska for work associated with the project (by state employees) and the anticipated permit, recording, and filing fees.

- Pipeline construction contractors could be heavily engaged in the rebuilding of Iraq, whenever this activity commences. Pipeline contractor involvement could impact project pricing and schedule.
- The cost of fuel is currently volatile, and rising, and may be anticipated to affect the cost of equipment and materials as well as transportation and construction costs.
- Pipeline equipment vendors may be involved in supplying materials and equipment for the rebuilding of Iraq, and this could impact equipment costs and material delivery schedules.
- Paragon assumed that rather than open cut rivers and streams (with the associated environmental issues relating to anadromous breeding fish) that the majority of these crossings would be constructed by the horizontal directional drill techniques, causing no river or stream environmental disturbance. Many crossings probably could only be done during specific windows of time, potentially requiring the construction spreads to move around the areas and remobilize to the area at a different time, all of which would involve additional expense.
- Paragon assumed that an environmental impact statement would very likely be required and has deemed it prudent to include the estimated cost for this activity in our estimate.
- The use of "line break" (rate of decline) main line valve pneumatic actuators are not generally recommended for a natural gas pipeline system, due to the potential for service interruptions to consumers. A rate of decline actuator's instrumentation can fail for various reasons, or a high peek (rapid) demand (exceeding the set point rate) such as a power plant quickly starting up, could result in the closure of a line break valve, thus shutting down the entire gas supply to consumers. Once shut, these line break operators must be manually reset (i.e. re-opened). Line break main line valve operators are especially not desirable when the reliability issues are considered (i.e.

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when equipment and system statistical mean time to failures, probability of failures, frequency of failures, and the consequences of failures are statistically determined by a reliability, availability and maintainability statistical Monte-Carlo type analyses (RAM)). The reliability of a gas pipeline and distribution system is especially important for major critical consumers such as electric power generating plants, which usually specify a specific minimum reliability required for gas feed sources. A gas supply interruption could potentially cause major problems, especially when considering the expense, time and good will associated with restarting an entire gas pipeline and distribution system. If a pipeline line brake should ever occur, sectionalizing valves can be manually closed to isolate the affected section of the pipeline. If desired, certain mainline sectionalizing valves may also be remotely automated and operated from the supervisory control and data acquisition (SCADA) system, or the leak detection system. Note that natural gas is lighter than air, and rises and disperses vertically into the atmosphere, and does not pollute the environment, as would a liquid spill. Paragon included the cost of four Emerson Process Management (Shafer) line break operators in the Paragon cost estimate, as did the original Stone and Webster cost estimate.

- Paragon assumed that major equipment and facilities (compressors, regulators, and meter systems, etc.) are barbed wire fenced and insulated and suitably winterized (enclosed or contained in insulated, lighted, ventilated buildings) for use in Alaska's winter environmental conditions.
- The use of commercially available natural gas "radiant" catalytic heaters (which are described in the original estimate's text for the heating of enclosed areas), which have sometimes been improperly installed inside of enclosed meter stations, regulator stations, compressor stations, etc. are not rated or recommend for these areas. The catalytic heaters have an open flame impinging on the high temperature ceramic element, which does not meet the National Electric Code's (NEC) area classification requirements (class 1, group D, division 1 or 2) for these hazardous enclosed areas. Only NEC approved heat sources should be utilized inside of hazardous areas.
- Paragon recommends that a state of the art statistical based leak detection system be used to monitor the pipeline system, in lieu of the older mass balance type systems. The statistical leak detection system produces very few false alarms when it is compared to the process based mass balance type leak detection software systems. The statistical leak detection system software also "learns" and accommodates pipeline steady state and normal transient conditions, and further alarms and determines the size and location of the leak. Operators of the process simulated mass balance type leak detection systems have been known to ignore (or turn off) a pipeline system's leak detection system's alarms, due to the high number of false alarms generated by the older process based leak detection simulation

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software (which is not an acceptable operating practice). The cost of the statistical leak detection system has historically been less than the process-based systems.

- Confirm that the natural gas supply obtained from the source (Beluga tie-in) is adequately water dew point dehydrated and hydrocarbon dew point controlled, in order to prevent water and hydrocarbon condensates from forming in the pipeline system (especially during winter conditions). It is undesirable for a natural gas pipeline system (or distribution system) to enter the two-phase flow regime, with the associated potential for: higher pressure loss (and reduced flow rates), hydrate formation, internal corrosion, and the potential for high BTU content hydrocarbon liquids being delivered to a consumer's lower BTU rated gas burners, with the potential for a very high flame flare up and higher heat content flame, potentially damaging burners. Confirm that the source of gas has a high availability (reliability).
- It would be advisable to have methanol injection facilities (to prevent hydrates) installed on the gas pipeline system, especially if the glycol dehydration systems of the natural gas source could ever deliver "off specification" gas to the pipeline system during upstream process upsets.
- If any chemical plants, refineries, etc. could be potential consumers and utilize the natural gas as a feed stream for the chemical processes, these facilities usually will not accept any mercaptan odorant added in the natural gas feed stream, because the sulfur compounds quickly foul the catalysts in the process equipment, causing operating problems, high catalyst maintenance costs, and resultant lost production costs. It is typical industrial practice to only mercaptan odorize the natural gas streams distributed to the consumers (but not odorize the gas in the main pipeline system).
- The custody transfer meter station should be equipped with a gas chromatograph to sample, analyze the molal gas composition, determine the gas specific gravity, and determine the BTU (heat) content of the gas stream. Many natural gas local distribution companies presently sell natural gas based upon the heat content, rather than on a volumetric total cumulative flow basis.
- It would be desirable conducting seismic analysis during the detailed engineering and design phase, as Alaska region is a geologically active seismic area.
- The Driscopipe, now Chevron-Phillips Chemical Company (CPChem Performance Pipe), SDR – 11, high-density polyethylene (HDPE) pipe mentioned for use in the low-pressure gas distribution system may be used for natural gas service. However, should any solvating or permeating hydrocarbon liquids (such as natural or other fuel-gas liquid condensates, crude oil, fuel oil, gasoline, diesel, kerosene, hydrocarbon fuels, etc.) ever form, or be present in greater than 2% concentrations, the manufacturer states that the hydrocarbon liquids may have a strength weakening effect on this material. The use of HDPE material should be carefully evaluated, if 2% or greater concentrations of permeating or solvating hydrocarbon

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liquids could ever be present in this distribution piping system. Pipeline winter operating temperatures, at a minus 3 foot burial depth, may be approximately 25 ^{0}F and above grade ambient temperatures are historically even colder, potentially causing liquid condensate to form in this distribution system piping.

- Pipeline system hydraulic modeling (pipeline simulations) utilizing commercially available pipeline system software should be performed to confirm the pipeline's sizing. Current "state of the art" pipeline system simulation software should be utilized to confirm the pipeline system's sizing, considering both steady state and transient operating conditions, under both winter and summer operating conditions. The Stone and Webster (1988) pipeline sizing calculations were very simplified and elementary. Current commercial pipeline system process simulators utilize the chemical engineering equations of state, and for each point (node) along the pipeline, determine the gas pressure, temperature, vapor fraction, liquid fraction, and consider the heat transfer effects of the local soil environment. These current pipeline simulation programs perform complete steady state and transient dynamic pipeline system analysis and have been utilized for many years to determine pipeline sizing and design. Dependent on the pipeline hydraulic simulation (modeling) required it is standard industry practice to employ different commercial software (having differing simulation capabilities) to simulate specific operating conditions. Some commercial programs are deemed better than others for certain specific engineering simulation needs, such as pipeline two-phase flow modeling.
- The overall accuracy "confidence level" of the cost estimate can be further improved by performing some additional work, involving the further solicitation and confirmation of the elemental cost pricing structure, which comprises the estimate. Verifying most of the major material, construction, and services costs would provide a narrowed (reduced) overall confidence interval, and improve the overall accuracy level of the cost estimate. In addition, the cost estimate's accuracy can be further improved by updating it after the completion of the preliminary engineering and design work and / or after the detailed engineering and design phases of the work. These items would serve to improve the estimate's overall accuracy at each stage of the work (confidence level) by providing improved project definition and complete specification.
- The Stone and Webster document mentions 125 streams and rivers in one section and then mentions 144 streams and rivers in a different section. This is an inconsistency in the text.
- The Stone and Webster distribution system cost estimate did not contain much detail indicating how the cost estimate was derived for this system.

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Sincerely,

PARAGON ENGINEERING SERVICES, INC.

Thomas F. Cross, P.E.
Vice President of On-Shore Pipeline engineering

Attachments:

Alaska Cost Chart 1
Alaska Cost Chart 2
16" Pipeline Cost Estimate w/5% contingency
16" Pipeline Cost Estimate w/10% contingency
20" Pipeline Cost Estimate w/5% contingency
20" Pipeline Cost Estimate w/10% contingency
24" Pipeline Cost Estimate w/5% contingency
24" Pipeline Cost Estimate w/10% contingency

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