DATA REQUEST REFERENCE INFORMATION

Agency	Data Request Date	Letter Request No.
ADEC	04-28-2020 (via e-mail)	RFI-679

REQUEST:

E-mail from Dave Jones (ADEC) on 4/28/2020 indicated:

The Department has been working on making changes to AGDC's GTP permit to address the comments we received from EPA, as well as spending time on the Liquefaction Plant permit. We are nearly complete with both permits (minus work on the increment inventory analyses) and have a couple of questions to help us proceed.

__GTP__

We received a comment from EPA stating:

The TAR briefly explains carbon capture sequestration (CCS) and concludes that the Department did not identify CCS as a control technology at any facility in the RBLC. The TAR should explain why CCS is technically infeasible as a technology transfer for this project. In doing so, the TAR should explain what happens to the CO_2 returned to the Prudhoe Bay Unit.

The AKLNG application document containing the GTP BACT Analysis (06_GTP Best Available Control Technology Analysis.pdf, dated December 2017) states on PDF page 66:

The Project does not believe that carbon capture is an applicable and available control option for the turbine exhaust from this Project. Notwithstanding this position, in 2010, the GTP engineering contractor prepared an engineering evaluation and cost analysis for post-combustion carbon capture of the GTP turbine exhaust CO_2. This information was scaled to reflect the current turbine configuration of the GTP and escalated to 2016. Because of the difficulties in capturing low concentration and low pressure CO_2, the costs are extremely high. The capital cost of a carbon capture system is estimated to be more than $3 billion. Even assuming 90% capture of the CO_2, resulting in avoided emissions of 4.2 million tons of CO_2 per year, the cost effectiveness is more than $900 per ton controlled[15].

[15] Doc No. USAG-WD-PRTEC-000045, Alaska Pipeline Project Gas Treatment Plant CO_2 Capture Study, March 18, 2010.

1) Please provide the referenced study and anything else AGDC believes would help the Department in responding to EPA's comment.

Liquefaction Plant

The emissions spreadsheet (Emission Calculations for LNG rev7.xlsx, submitted May 1, 2018, attached) contains emission factors for the thermal oxidizer EU 13 that are based on "TCEQ Vapor Oxidizer Emission Factors."

2) Please provide the TCEQ document or webpage that contains these emission factors.

Increment Consumption Analysis for Both Facilities

3) Please provide the Department with an update on the progress of the updated increment consumption analyses for both facilities.

ALASKA LNG RESPONSE:

GTP

1) **Please provide the referenced study and anything else AGDC believes would help the Department in responding to EPA's comment.**

Attachment 1 is a copy of the requested document. Additional information is provided below to support the ADEC response to the EPA request.

Carbon capture and storage (CCS) is a geo-engineering technique used to remove the CO_2 from an exhaust gas stream and permanently store the gas in underground reservoirs or other geological features. The technology captures carbon dioxide (CO_2) before the gas enters the atmosphere, compresses the CO_2 to a near liquid state, and transports the gas via pipeline to a site for injection deep underground. The deep geological formations that receive and hold CO_2 must be far below freshwater aquifers and below an impermeable cap rock or seal so the CO_2 does not contaminate ground water or escape to the atmosphere. Ideal geological formations for sequestration include depleted oil and gas fields and deep ocean masses.

While the technology for the post-combustion capture CO_2 may be available, the process has not yet been demonstrated in practice for combustion turbines. Operating such a system in a remote arctic environment presents challenges that are not easily overcome. Additional equipment, operating complexity and utilities consumption (e.g. power, water, air, etc.) would all accompany a carbon capture system at the GTP. This additional equipment would increase the electrical demand and therefore significantly increase the size of the power generation system, which would result in additional air pollutant and noise emissions and waste generated at the site.

CCS is an emerging technology that has no successful industrial scale application on the North Slope or elsewhere in Alaska. Successful CCS has not been demonstrated on any similar projects, regardless of location. Carbon capture is being studied by the U.S. Department of Energy, the Electric Power Research Institute (EPRI), and others for application to much larger fossil fuel-fired boilers. As noted above, carbon capture for combustion turbines is much more difficult because the CO_2 in the turbine exhaust is much more dilute as compared to boilers. The conclusion is that CCS is not an available control technology for the GTP.

Liquefaction Plant

2) **Please provide the TCEQ document or webpage that contains these emission factors.**

The emission factor reference provided in the Liquefaction Facility emissions spreadsheet, *Emission Calculations for LNG rev7.xlsx*, for the thermal oxidizer (Emissions Unit (EU) No. 13) is the Texas Commission on Environmental Quality (TCEQ) *New Source Review Emission Calculations for Vapor Oxidizers* document, dated January 2008. The reference is provided in Attachment 2, and can be accessed at:

https://www.tceq.texas.gov/assets/public/permitting/air/Guidance/NewSourceReview/emiss_calc_vaporox.pdf

The emission factors in this reference were used for estimating potential nitrogen oxides (NO_X), carbon monoxide (CO), volatile organic compounds (VOC), and particulate matter (PM_{10} and $PM_{2.5}$) emissions from EU 13. The emission factor reference indicates that vapor oxidizer emission factors for CO, VOC, PM_{10}, and $PM_{2.5}$ should be based on the emission factors that are provided for the respective pollutants in the U.S. Environmental Protection Agency (EPA) AP-42: Compilation of Air Emission Factors, Section 1.4, Natural Gas Combustion, Tables 1.4-1 and 1.4-2. The TCEQ reference indicates that NO_X emissions from vapor oxidizers are generally expected to be less than 0.10 pounds per million British thermal units (lb/MMBtu). This emission rate, which was used in the Liquefaction Facility emissions spreadsheet, is comparable to the NO_X emission factor derived from AP-42, Section 1.4, Table 1.4-1, for uncontrolled NO_X emissions from small (<100 MMBtu/hr, heat input) natural gas-fired boilers.

Increment Consumption Analysis for Both Facilities

3) **Please provide the Department with an update on the progress of the updated increment consumption analyses for both facilities.**

AGDC completed the increment analysis for the GTP facility on 4/20/2020 and provided a set of slides to ADEC's lead modeler (Jesse Jack) on that day. We had an on-line working session with Jesse on 4/21/2020 to review the approach and conclusions of the work. Jesse indicated at that time that he would review it and let us know if he had any feedback.

We understood Jesse's plan was to review the GTP work and then tell us if anything more was needed. After receiving this request for information, AGDC checked in again with Jesse (4/29/2020) to make sure our understanding was correct, and confirmed his plan is to go over our materials internally within ADEC and then circle back with the group as soon as possible to discuss next steps. If we can be of any assistance in that process, or if the broader team would like a presentation of the information, please let us know.

AGDC is meantime continuing forward on the LNG facility work using the same approach used for the GTP. On 4/24/2020, we asked Jesse for additional information on sources near the LNG facility (the 'initial permit' column of the spreadsheet provided by ADEC previously). On 4/28/2020, Jesse asked for a clarification on our request, and on 5/4/2020 we provided that clarification. As soon as the data is available, we will continue to progress the LNG facility increment analysis using the same approach we used for GTP.

ATTACHMENTS:

1. Doc No. USAG-WD-PRTEC-000045, Alaska Pipeline Project Gas Treatment Plant CO2 Capture Study, March 18, 2010.
2. Texas Commission on Environmental Quality, New Source Review (NSR0 Emission Calculations, Vapor Oxidizers, January 2008.

TransCanada

ExxonMobil

Alaska Pipeline Project

Gas Treatment Plant

CO_2 Capture Study

Document No USAG-WD-PRTEC-000045

Rev	Rev Date	Description	Prepared By	Checked By	Approved By	Endorsed (EM/TC)
0	3/18/10	Issued for Information	TRR	SAH	WMM	

URS

Project No. 29869-001

APP PROPRIETARY

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ATTACHMENTS:

Attachment A – Estimate

Attachment B – Preliminary Plot Plan with CO_2 Capture

1.0 INTRODUCTION

The Alaska Pipeline Project (APP) requires a Gas Treating Plant (GTP) to process residue gas from the existing Central Gas Facilities (CGF) at Prudhoe Bay. The GTP will be designed to extract CO_2 and H_2S, dehydrate, compress and then chill the treated CGF residue gas to provide a sales gas stream that will meet the project sales gas specification. The GTP will process sufficient quantities of gas (about 5,300 MMSCFD) to maintain average daily sales gas delivery of 4,500 MMSCFD.

The GTP will generate its own electricity. The facility will include three large compression services (sales gas, CO_2 and refrigeration) that will be turbine driven. A portion of the sales gas will be utilized to supply these drivers as well as the gas turbine generators that will provide power to meet the remaining demands. Operation of these turbines will result in the discharge of over 11,000 mT/d (12,000 st/d) of CO_2 to atmosphere.

This document describes the objectives, basis, results and conclusions of a study intended to define and estimate the facilities necessary to capture CO_2 from turbine flue gas and reinject it, should there be a limit imposed on CO_2 emissions.

2.0 EXECUTIVE SUMMARY

The scope of the CO_2 capture study included determining the facilities necessary to capture CO_2 from the flue gas of the many turbines in the GTP, and then estimating the additional project cost associated with implementation. Flue gas sources identified for the study include the turbine drives serving the Sales Gas Compressors, Propane Compressors and CO_2 Compressors, as well as the turbine generators supplying GTP electricity.

The flue gas feeding the CO_2 Capture facilities was assumed to have a CO_2 concentration of 3.46 mol% and a temperature of 380°F. Flue gas blowers were added at each source to overcome the pressure loss through the piping / ductwork and capture facilities. MEA was selected as the post combustion capture solvent, as amines are currently the most commercialized technology for flue gas applications. A 35 wt% solution was specified as a means to try and approximate a Fluor Econamine FG Plus^{SM} design. The flue gas is cooled upstream of the MEA system to maximize performance.

Based on the plot plan and equipment size limitations, the preliminary design includes four CO_2 Capture trains. Implementation of CO_2 capture requires the addition of CO_2 compression and dehydration capacity to handle the additional load. A substantial amount of additional piping and ductwork is also required to route the flue gas and captured CO_2 as needed.

The capital and operating costs and performance of the preliminary CO_2 Capture design are summarized in Table 1.

Table 1: Summary of CO_2 Capture for TransCanada GTP

TIC, $MM			
Flue Gas Blowers	$131.6 *		
CO_2 Capture Trains 1-4	$1,345.6 *		
Additional Earthwork Trains 1-4	$933.3 *		
Additional CO_2 Compression	$491.7		
Additional CO_2 Dehydration	$185.8		
Additional Piping / Ductwork	$543.7 *		
TOTAL	$3,631.8		
Operating Costs, $MM/yr			
	Electricity	Fuel Gas	Heat
TOTAL	$54.7	$38.0	$92.1
TOTAL all OPEX	$184.9		
Total CO_2 Capture Facilities			
Total CO_2 to CO_2 Capture, st/d	16,086		
Total CO_2 Captured, st/d	14,448		
%	90%		
CO_2 to Atm *without* CO_2 Capture, st/d	12,179		
CO_2 to Atm *with* CO_2 Capture, st/d	1,638		
CO_2 Avoided, st/d	10,541		
%	86.6%		

* - The TIC for these areas was not quantified individually. TIC shown above was approximated by taking the area DFC and multiplying by 2.822, which is the ratio between the total TIC for these areas over the total DFC for these areas.

With an estimated installed cost of $3.6 billion, this study clearly indicates that CO_2 Capture is an extremely costly undertaking. Early indications are that the cost to implement CO_2 Capture would approach half the value of the entire facility itself, without CO_2 Capture.

3.0 REFERENCES

1. Reddy, S., J. Scherffius, S. Freguia, and C. Roberts, "Fluor's Econamine FG Plus[SM] Technology: An Enchanced Amine-Based CO_2 Capture Process", Presented at the Second National Conference on Carbon Sequestration, May 5-8, 2003, Alexandria, Virginia.

4.0 DEFINITIONS

APP	Alaska Pipeline Project
CAPEX	Capital Expenditure
CGF	Central Gas Facility
DFC	Direct Field Cost
EOR	Enhanced Oil Recovery
FGD	Flue Gas Desulfurization
GTP	Gas Treatment Plant
hp	Horsepower
HRU	Heat Recovery Unit
ISO	International Organization for Standardization
st/d	Short ton per day (short ton = 2000 lbs)
MEA	Monoethanolamine
MMSCFD	Million Standard Cubic Feet Per Day
mT/d	Metric ton / day (1000 kg or 2205 lb)
OPEX	Operating Expenditure
TIC	Total Installed Cost

5.0 STUDY DESCRIPTION

The CO_2 Capture study is intended to define and estimate the facilities necessary to capture CO_2 from turbine flue gas and reinject it, should there be a limit imposed on CO_2 emissions. As part of the study, a technology was selected for post-combustion CO_2 Capture. Simulations were performed to allow system definition and sizing of the associated equipment. Finally, capital and operating costs were determined to quantify the economical impact of a limit on CO_2 emissions.

6.0 STUDY BASIS

6.1 Feed (Flue Gas)

This study is based on capturing CO_2 from the flue gas of the large compressor turbine drivers and the power generation turbines. For the purposes of the study, the flue gas sources and turbine sizes were identified to be the following:

- Propane Compressor Driver (GE LM2500+), 1 operating, 1 spare
- Sales Gas Compressor Driver (Frame 7EA), 4 operating, 1 spare
- CO_2 Compressor Driver (Frame 6B), 6* operating, 1 spare
- Power Generation Turbines (Frame 6B), 3 operating, 1 spare

*At the time of this study, the base GTP design only required four operating CO_2 compressors. However, the CO_2 captured from the various flue gas sources must also be compressed for injection. This required the addition of two more CO_2 compressors. These additional compressors were assumed to be driven by Frame 6B turbines as well.

GE provided a flue gas rate and composition from a LM2500+ engine based on a fuel gas composition provided by URS Washington Division. This composition was assumed to be representative of the flue gas from both the Frame 7EA and 6B machines as well. The fuel and flue gas compositions assumed for this study are shown in Table 2 below.

Table 2: Fuel and Flue Gas Compositions

Component Mol %	Fuel Gas (Dry)	Flue Gas Feed to CO_2 Capture (Wet)
C_1	89.47%	
C_2	6.18%	
C_3	2.11%	
C_4	0.30%	
C_5	0.04%	
C_6	0.02%	
H_2S	1 ppmv	
CO_2	1.20%	3.46%
N_2	0.68%	74.79%
Ar		0.89%
O_2		13.45%
H_2O		7.41%
TOTAL	100%	100%

Flue gas from the turbines flows through heat recovery units (HRU) to transfer energy to the GTP heat medium system. The flue gas was assumed to exit the HRU's at 380°F.

In order to obtain the flue gas rates for the other turbines, the LM2500+ flue gas rate was scaled by both the corresponding ISO power rating and the efficiency. The assumed ratings, efficiencies and single-machine flue gas rates are shown in Table 3 below.

Table 3: Turbine Ratings, Efficiencies, and Flue Gas Rates

Turbine	LM2500+	Frame 6B (Driver)	Frame 6B (Generator)	Frame 7EA
ISO Rating (hp)	42,000	58,380	56,457	115,630
Efficiency	41.1%	33.3%	32.1%	33.1%
Flue Gas Rate, lbmol/hr (based on fuel from Table 2)	24,978	42,852	42,990	85,388

Please note that supplemental firing is required in the HRU's to meet the GTP's total heating demand. The extent of this firing was unknown when the study commenced. Current calculations indicate that the flue gas from all the turbines could be approximately 25% short of providing the required GTP heat. The additional flue gas generated from the supplemental firing has *not* been included in the study. Increased flows to the CO_2 capture facilities will increase the system costs.

6.2 Technology Selection

The most commercialized technology to remove CO_2 from flue gas utilizes amine solutions. Therefore, an amine-based solvent system was selected as the basis of the CO_2 Capture design for this study. Current post-combustion capture installations use proprietary amine solutions, many of which are based on MEA. These include solvents offered by Fluor (30 wt% MEA) and Kerr-McGee / ABB Lummus (15-20 wt% MEA). Fluor's CO_2 capture technology has more commercial installations than that of Kerr-McGee / ABB Lummus.

The proprietary components of the Fluor's MEA-based Econamine FG Plus^{SM} serve to:

- Increase reaction rates (though the predominant amine remains MEA)
- Allow higher solvent CO_2 loading
- Minimize degradation and corrosion

In order to permit system simulation and avoid relying on the receipt licensor proposals, MEA was selected as the amine for the post-combustion CO_2 capture designs in this study. A 35 wt% solution was specified as a means to try and approximate the claimed increased reactivity of Fluor's 30 wt% Econamine FG Plus^{SM}. Bryan Research and Engineering's (BR&E) Promax software was used as a simulator.

6.3 System Configuration and Description

<u>Flue Gas Blowers</u>

Flue gas exiting the turbines will go through a heat recovery unit (HRU) to transfer energy to the GTP heat medium system. Flue gas will exit the HRU at approximately 380°F. Without CO_2 capture, the gas would flow through a stack and be vented to atmosphere. With CO_2 capture, the flue gas will have to be boosted in pressure to overcome the pressure drop through the downstream ductwork and CO_2 Capture system, which includes two packed towers. Standard combustion turbines are designed for a maximum backpressure of about 20"w.c. Operating with higher backpressures would cause upsets in the cooling air distribution to the last row of nozzle and rotor blades, and also could result in backflow of exhaust gas through the shaft seals. Consequently, an exhaust gas boost blower was included in the system design to allow use of a standard-design combustion turbine. Each turbine will have a dedicated blower located as close as possible to the HRU exit.

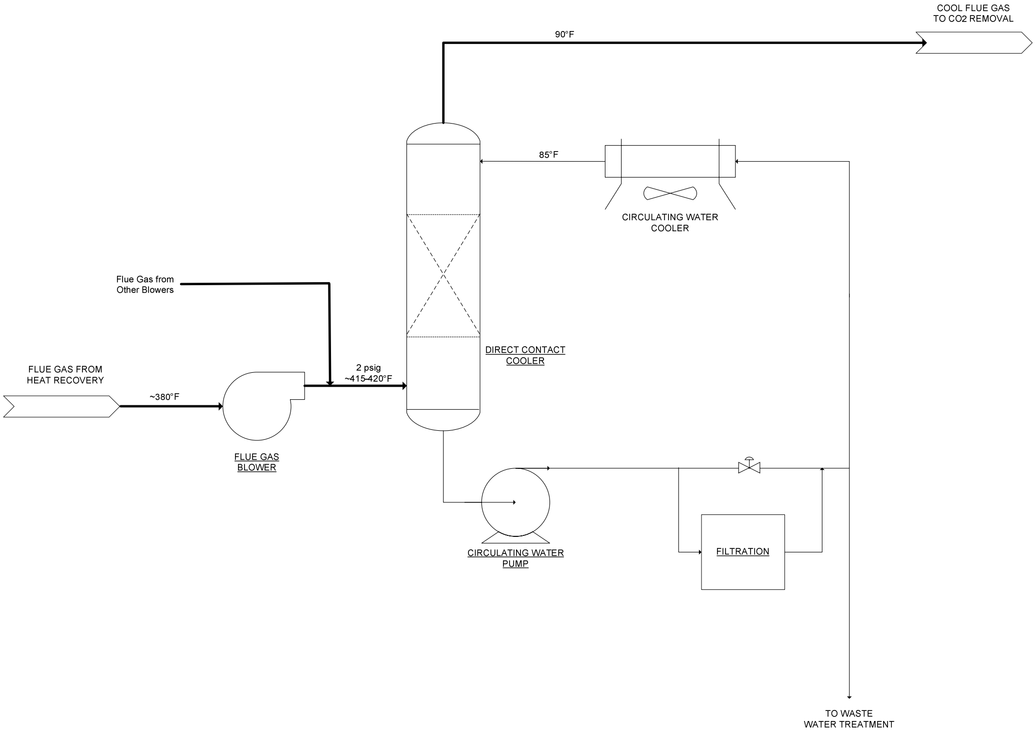
Flue gas from the individual blowers will be combined and travel through a potentially significant length of ductwork to a CO_2 Capture train. If CO_2 Capture is implemented, a detail hydraulic analysis would be required to determine the required head of the flue gas blower. For the purposes of the study, the blower was assumed to have a discharge pressure of 2 psig.

Flue Gas Cooling

Amine units operate most effectively with a relatively cool gas feed (~90-120°F) due to the associated reaction equilibrium. Flue gas will exit the blowers at approximately 415-420°F and therefore must be cooled upstream of the solvent system. This can be accomplished indirectly with an air cooler followed by a separator to recover the condensed water, or directly by contact with a circulating water stream in a dedicated tower.

The direct cooling method is considered by some to be less costly (URS Washington Division has not confirmed this). A contactor also enables the operator to inject caustic into the circulating water stream. This is commonly done in similar towers in Tail Gas Treating Units. This ability could be beneficial if there is any SO_2 in the flue gas. SO_2 results in the formation of non-regenerable degradation products in the downstream amine solvent, causing unwanted solvent losses. For these reasons, the direct cooling method was selected as the basis for this study. Figure 1 provides a simplified PFD of the blower and flue gas cooling.

Figure 1: Flue Gas Blower and Cooling Simplified PFD



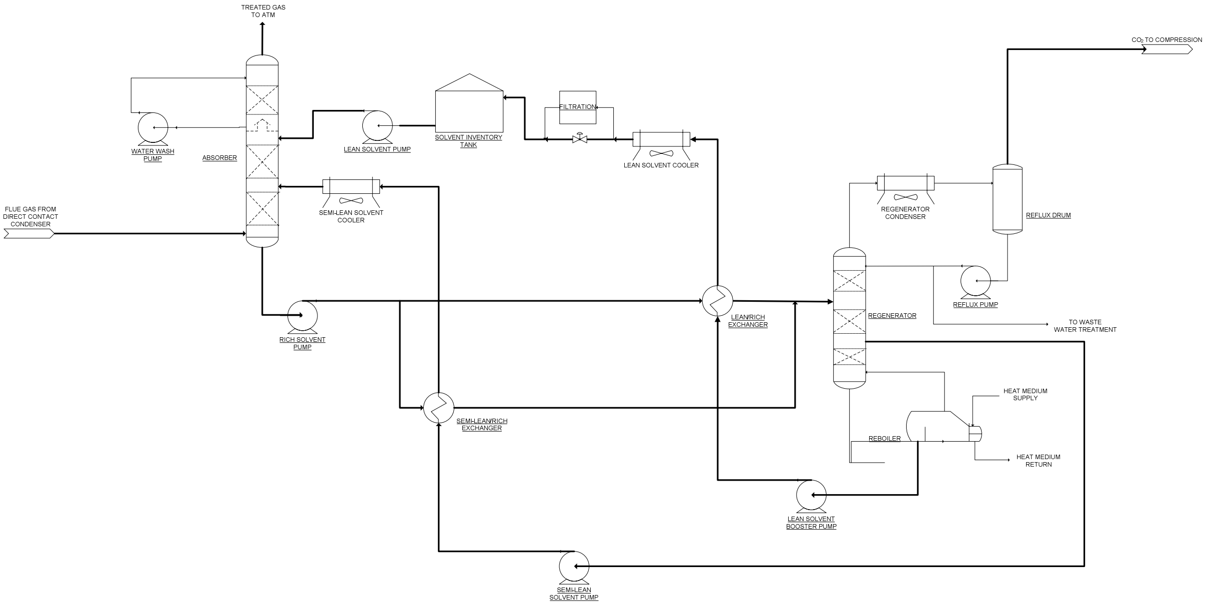
Flue gas from the source blowers enters a Direct Contact Condenser. In this tower the flue gas is contacted counter-currently with a circulating water stream to cool the flue gas to 90°F. The tower utilizes structured packing to minimize pressure drop. Water from the bottom of the tower is pumped and a slip stream is routed through filtration. (Filtration is always included in similar services in Tail Gas Treating Units, however this service should be significantly cleaner and a possibly optimization / cost savings measure may be to eliminate the filtration.) Approximately 1% of the circulating water stream is routed to water treatment to dispose of water condensed during cooling. The balance of the circulating water stream is cooled to 85°F in an air cooler and returned to the tower.

The cool overhead gas stream continues on to the amine system.

<u>Amine Unit</u>

Fluor and others typically propose advanced amine unit designs that may include lean / semi-lean configurations, absorber side coolers, flash drums, or combinations thereof. URS Washington Division recommends the configuration represented in Figure 2, as our experience indicates this to be economically optimal when both operating and capital costs are considered.

Figure 2: Post-Combustion CO_2 Capture Amine Unit Simplified PFD



For the purposes of the study, the unit was designed to capture 90% of the CO_2 entering the Absorber. Most industry publications regarding post-combustion CO_2 capture use this basis. Recent study by URS Washington Division also indicates that CO_2 absorption becomes more difficult, and therefore more expensive, above 90% capture.

Cool flue gas from the Direct Contact Cooler enters the Absorber, where the gas is contacted counter-currently with a 35wt% MEA solution. The Absorber contains two absorption beds and one water wash bed. Semi-lean amine is routed to the top of the bottom bed, and lean amine enters at the top of the middle bed. A water wash bed is included at the top to mitigate the loss of MEA. All beds are packed with structured packing to minimize pressure drop. Treated gas from the Absorber exits a stack to the atmosphere.

Rich solvent from the Absorber bottoms is pumped and then split for cross exchange in the Lean / Rich and Semi-Lean / Rich Exchangers. The rich solvent effluent from these two exchangers recombines and enters the Regenerator for stripping. The Regenerator includes two stripping beds and one reflux bed. The rich solvent enters at the top of the middle bed. After some steam stripping, a semi-lean solvent stream is extracted between the bottom two beds. Semi-lean solvent from the Regenerator is pumped through the Semi-Lean / Rich Exchanger and Semi-Lean Solvent Cooler to the Absorber.

The remaining solvent is stripped further in the bottom bed of the Regenerator to create a lean solvent stream. Lean solvent exits the kettle reboiler and is pumped through the Lean / Rich Exchanger, Lean Solvent Cooler and filtration before entering the Solvent Inventory Tank. From the inventory tank the lean solution is pumped to the Absorber.

CO_2 from the Regenerator overhead is cooled in the Regenerator Condenser before entering the Reflux Drum where water is separated and returned to the top bed of the Regenerator. CO_2 from the

Reflux Drum joins other CO_2 streams from the GTP in the low pressure CO_2 header feeding the CO_2 Compressors.

At the time of this study, the base GTP design only required four operating CO_2 compressors. However, the CO_2 captured from the various flue gas sources must also be compressed for injection. This required the addition of two more CO_2 compressors.

Additional CO_2 Compression / Dehydration

As previously mentioned, the CO_2 from the CO_2 Capture Regenerators must also be compressed for injection. The additional load requires the addition of two CO_2 compression and dehydration units. The capacity of these new compressors is similar to that of the CO_2 compressors planned for the GTP; as such, these additional compressors were assumed to be driven by Frame 6B turbines as well.

Additional Piping / Ductwork

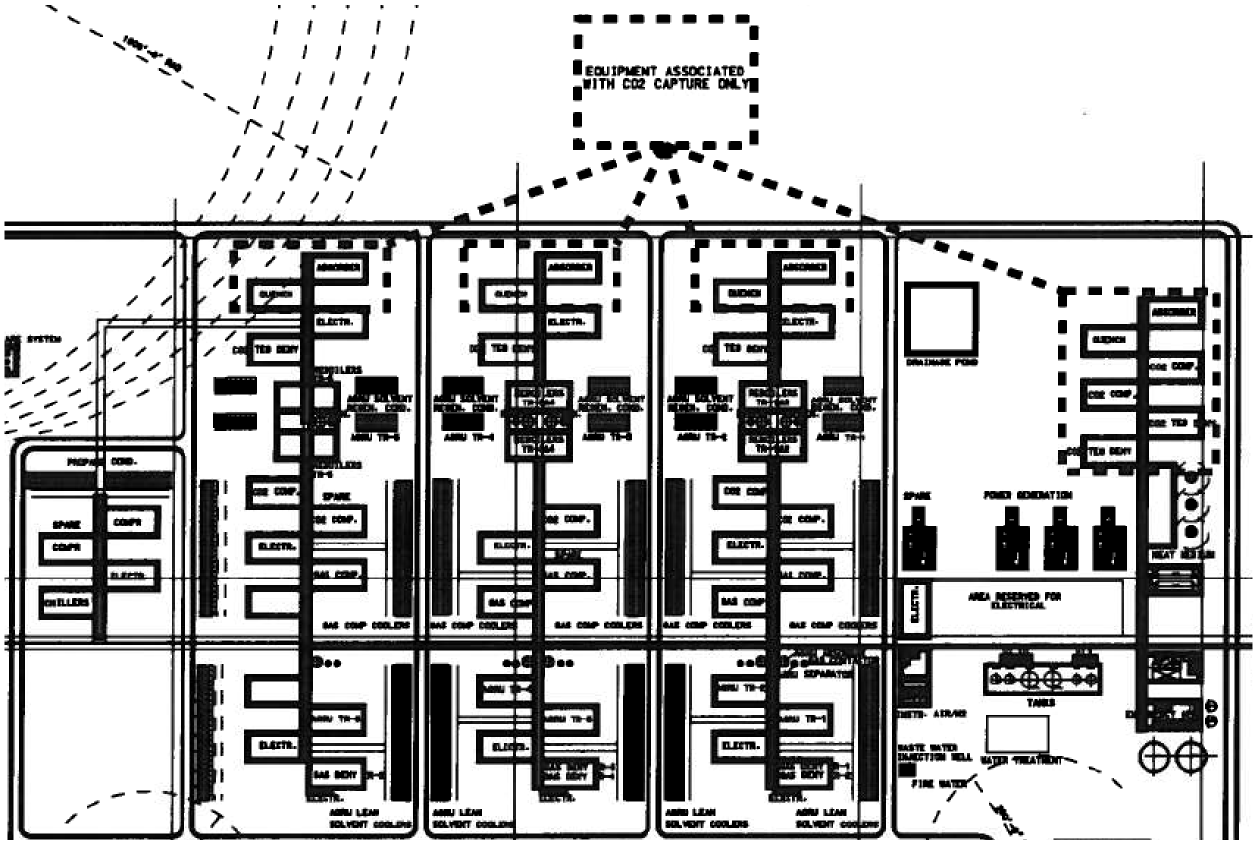
To enable CO_2 Capture, several units are required that must be connected. This necessitates the addition of a significant amount of ductwork and piping. A very rough estimate of the size and length of the additional piping and ductwork was made to estimate these costs. These new lines include:

- Ductwork from individual flue gas blowers to corresponding CO_2 Capture Train (see next section for logic behind the number of trains.)
- Low pressure CO_2 piping from each CO_2 Capture Regenerator to the low pressure CO_2 Header
- Increase in size of CO_2 headers (all pressures) already planned for base GTP
- Additional CO_2 header (all pressures) length to accommodate CO_2 from fourth CO_2 Capture train.
- Piping to and from the two additional CO_2 compression and dehydration units.

6.4 Trains

The number of trains is dictated by plant layout and Absorber size limitations. At the time this study commenced, the plot plan was still under development. However, the gas treating systems were generally arranged in three north - south sections, with power generation in a separate section to the east and the propane compressors in a separate section to the west. The addition of CO_2 Capture necessitates the addition of two CO_2 Compressors. These were assumed to be in the same vicinity of the turbine generators. This layout lends itself to four CO_2 Capture Trains. Figure 3 shows an excerpt from the preliminary plot plan including CO_2 Capture that was used as the basis for this study. The full drawing is available as Attachment B.

Figure 3: Preliminary Plot Plan Including CO_2 Capture



On this basis, the four CO_2 Capture trains would be of unequal size, each handling specific turbines of the nearest vicinity. Table 4 summarizes the turbines that feed each CO_2 Capture Train.

Table 4: Turbines Feeding Each of the Four CO_2 Capture Trains

	Train 1	Train 2	Train 3	Train 4
Propane Compressor Turbine Drives (LM2500+)	1	0	0	0
Sales Gas Compressor Turbine Drives (Frame 7EA)	1	2	2	0
CO_2 Compressor Turbine Drives (Frame 6B)	2	1	2	2
Turbine Generators (Frame 6B)	0	0	0	3

The next step was to confirm that these four trains could be accommodated in a single Direct Contact Condenser and Absorber per train. These towers are not standard gas treating towers, which are typically shop-fabricated, code vessels. These towers operate near atmospheric pressure, and as a result handle very large volumetric flows. The services are most like flue gas desulfurization (FGD) scrubbers in coal fired power plants. Such FGD scrubbers are field fabricated and have design pressures less than 5 psig.

Such towers can be cylindrical or square in geometry. The advantage of a cylindrical tower is that it is more familiar, and there are more operating cylindrical towers than square towers. The advantage of a square tower is that it takes up less plot space for the same amount of cross-sectional area. Table 5 summarizes URS Washington Division's knowledge of both square and cylindrical flue gas scrubbers.

Table 5: URS and Industry Experience with Flue Gas Scrubbers

Geometry	Max ID - URS	Max ID - Industry	Metallurgy	No. of URS applications in large range
Square	~55-60 ft square	70 x 70 ft	Primarily resign lined CS, plus all those listed for cylindrical except FRP – There is talk of square FRP towers and possible 1 installation in Japan	10-15
Cylindrical	80ft	120 ft	FRP, Lined CS, 2205, solid C276, alloy G, clad austenitic SS, multiple alloys at various levels in tower, 317 LMN, 6 MO, Stebbins Tile	50+

More study would be required to determine which geometry is more economical in a specific location. For the purposes of this study, the towers were assumed to have a square geometry to conserve plot space and lined CS metallurgy.

For the proposed Trains 1-4, the towers would have dimensions ranging from 45 ft x 45 ft to 58 ft x 58 ft. This is within the experience range of URS Washington Division and thus the four train basis was retained for the study.

6.5 Operating Costs

Operating costs for this study are based on the following:

Electricity: 7¢/kWh

Fuel Gas: $4/MMBtu HHV

Heating: $5/MMBtu (fuel value based on 80% efficiency heat transfer to heating medium)

At this point in the project, no value has been assigned to coolant, water (all types), instrument and service air, or nitrogen. The operating costs of those commodities are not included in the costs presented in this study.

7.0 RESULTS

Table 6 summarizes the results of the CO_2 Capture facility design associated with the TransCanada GTP.

Table 6: Summary of Results

	Propane Compressor Turbine Drive (1+1, LM 2500+)	Sales Gas Compressor Turbine Drive (4+1, Frame 7EA)	CO_2 Compressor Turbine Drive (6+1, Frame 6B)	Turbine Generator (3+1, Frame 6B)
Flue Gas Blowers				
Bhp per blower	2,632	8,997	4,515	4,530
	Train 1	Train 2	Train 3	Train 4
Flue Gas Cooling				
CO_2 in Feed, st/d	3581	3901	4684	3920
Mol% CO_2 in Feed	3.46%	3.46%	3.46%	3.46%
Circulation Rate, gpm	23,484	25,587	30,720	25,712
MEA System				
Mol% CO_2 in Feed	3.57%	3.57%	3.57%	3.57%
CO_2 Captured, st/d	3,216	3,504	4,207	3,521
%	90%	90%	90%	90%
Semi-lean Circulation Rate, gpm	4,756	5,182	6,221	5,207
Lean Circulation Rate, gpm	2,952	3,217	3,862	3,233
Total Circulation, gpm	7,708	8,399	10,083	8,440
Total CO_2 Capture Facilities				
Total CO_2 to CO_2 Capture, st/d	16,086			
Total CO_2 Captured, st/d	14,448			
%	90%			
CO_2 to Atm *without* CO_2 Capture, st/d	12,179			
CO_2 to Atm *with* CO_2 Capture, st/d	1,638			
CO_2 Avoided, st/d	10,541			
%	86.6%			

Note that the numbers shown for CO_2 vented to atmosphere with and without capture only include emissions from the turbines.

Table 7 summarizes the capital and operating costs associated with the addition of CO_2 Capture to the TransCanada GTP. The capital costs are based on North Slope, modular installation.

Table 7: Capital and Operating Costs of CO_2 Capture

TIC, $MM			
Flue Gas Blowers	$131.6 *		
CO_2 Capture Trains 1-4	$1,345.6 *		
Additional Earthwork Trains 1-4	$933.3 *		
Additional CO_2 Compression	$491.7		
Additional CO_2 Dehydration	$185.8		
Additional Piping / Ductwork	$543.7 *		
TOTAL	$3,631.8		
Operating Costs, $MM/yr			
	Electricity	Fuel Gas	Heat
Flue Gas Blowers	$36.3	$0	$0
CO_2 Capture Trains 1-4	$17.2	$0	$91.7
Additional CO_2 Compression	$1.2	$38.0	$0
Additional CO_2 Dehydration	$0.1	$0	$0.4
TOTAL	$54.7	$38.0	$92.1
TOTAL all OPEX	$184.9		

* - The TIC for these areas was not quantified individually. TIC shown above was approximated by taking the area DFC and multiplying by 2.822, which is the ratio between the total TIC for these areas over the total DFC for these areas.

These results reveal that the facilities and costs associated with the implementation of CO_2 Capture are very extensive. The equipment itself would substantially increase the plot requirements for the plant. Early indications are that the $3.6 billion capital investment would approach half the value of the entire treating facility.

8.0 FURTHER ACTIONS REQUIRED AND OPEN ITEMS

- Supplemental firing is required in the HRU's to meet the GTP's total heating demand. The extent of this firing was unknown when the study commenced. Current calculations indicate that the flue gas from all the turbines could be approximately 25%

short of providing the required GTP heat. The additional flue gas generated from the supplemental firing has *not* been included in the study. Increased flows to the CO_2 capture facilities will increase the system costs.

- If CO_2 Capture becomes a requirement, other possible post-combustion technologies should be considered. There are two licensors, Alstom and Powerspan, who offer ammonia-based solvent processes that are in demonstration stage. In addition, there are newly developed specialty amines. Proposals should be obtained for these processes, as well as processes based on proprietary amines.

- Only shell and tube type exchangers were specified for cross exchangers. The use of plate and frame type exchangers might offer some cost savings.

- If CO_2 Capture becomes a requirement, a study should be done to determine whether square or cylindrical towers are more economical.

ATTACHMENTS:

Attachment A – Estimate

Attachment B – Preliminary Plot Plan with CO_2 Capture

TransCanada Class V Estimate Studies
Basis of Estimating Scope for North Slope Alaska Modular Estimates
Used on CO2 Capture Study May 21, 2009

CO2 CAPTURE STUDY

- Equipment list from the project team has defined each area/system for:
  - Area Flue Gas Blowers Common, to be incorporated into 5,000ton process equipment modules
  - Area Flue Gas Quench Train 1
  - Area CO2 Capture Train 1
  - Scaling factors to be used with cost exponent (.65) for Flue Gas Quench and CO2 Capture for trains 2 (1.089), 3 (1.308) & 4 (1.094)
  - Scaling factor based on compressor HP to be used with cost exponent (.65) for CO2 Gas Compression area/system costs based on Case 7a/11a study, increased to 2 trains and adjusted to NS Modular basis at Total Installed Costs (TIC) only
  - Scaling factor (.905) to be used with cost exponent (.65) for CO2 Dehydration area/system costs based on Case 12a Alt 1 study, increased to 2 trains and adjusted to NS Modular basis at Total Installed Costs (TIC) only
- Equipment list from the project team has defined each area/system with equipment components identified with minimum Conditions of Service (CoS) for pricing using in-house estimating system, except for:
  - In cases where the Equipment List Conditions of Service (CoS) is too large for the Kbase CoS the quantity has been adjusted with the Kbase reduced capacity to match the overall capacity

ESTIMATING BASIS FOR BOTH STUDIES

- All process systems will be built as modular construction estimated as fabricated in the Lower 48 (L48) USA at a Module Fabrication Yard (MFY).
- Equipment list does not define equipment onto individual modules
- Individual module sizes have not been developed.
- Overall module requirements and costs are based on weight of equipment
- Piperack and pipe in rack estimate is based on dimensions from the plot plan, which is fabricated in the L48 Module Fabrication Yard (MFY), USA
    - Process modules include piperack as defined on the plot plan
    - Piperack only modules have been defined from the plot plan
- An estimate of North Slope (NS) foundation requirements has been included based on the following assumptions:
    - Local mined, hauled and placed gravel, 6' thick under all modules (Process & Piperack) to be placed in the previous year
    - Slurry friction piles every 20' of length (width is 20' or less) for each piperack module, driven the previous year.
    - Slurry friction piles every 20 square feet under each process module, driven the previous year.
- Setting and interconnection of all modules at final plant site has been included
- Installing power cables (supplied by the L48) in tray, on piperack modules at the NS final site after setting and interconnection
- L48 Module Fabrication Yard (MFY) construction labor has been estimated based on an all-in subcontractor rate of $60.00
- North Slope Alaska construction labor has been estimated based on an all-in subcontractor rate of $300.00
- Bargeable Modular Design Strategy and Approach:
    - Larger, heavier, modules have the lowest unit cost, transferring the most man hours from the plant site to the Module Fabrication Yard (MFY). However, modules that are so large that they require special, costly, transportation methods will be avoided. Module weights are generally restricted by the carrying capacity of the Hydraulic Platform Trailers. URS-WD has established the following guidelines for module design:
        - Minimum TARGET module weight is 4,275 Standard Tons (ST)
        - Maximum module weight is 5,700 ST
        - Preferred module size is 76 ft. X 160 ft. (length allows for two modules to be placed on each barge, width allows for good access on port and starboard sides)
        - Maximum module size is 85 ft. X 220 ft.
        - Maximum vertical vessel present in a module is 200 ST & 60 ft. in height (to be evaluated on a case by case basis)

    - Maximum storage tank diameter shipped on a module is 60 ft.
    - All process, utility, and electrical equipment will be installed and tested in modules at the Module Fabrication Yard (MFY).
        - o All piping, electrical, instrumentation, insulation and painting will be completed and tested at the Module Fabrication Yard (MFY). Exceptions to this will be heavy vertical pressure vessels (over 60' high or more than 200 Standard Tons) and similar equipment that may be restricted by logistical clearances, or rig and haul limitations.
        - o Tanks larger then 60' in diameter will be field erected, smaller tanks may be skid mounted and transported to site. However, the guidelines regarding transport of oversize tanks and vessels will be evaluated by the logistics team on a case by case basis based on engineering and process requirements.
        - o Piperacks will be modularized, with all piping, cable tray, conduit, insulation, painting, anchors and supports installed.
        - o All stacks will be installed at the plant site.
        - o Vessel internals and heater refractories will be installed prior to transport at the Module Fabrication Yard (MFY). However, no catalysts or chemicals will be present until after arrival and the installation of modules at the site.
- This North Slope Alaska estimate includes an allowance for module transportation, as follows:
    - Land transportation of modules from L48 Module Fabrication Yard (MFY) onto barge
    - Sealift transportation of modules from L48 Module Fabrication Yard (MFY) dock to North Slope
    - Land transportation of modules from barge at plant site dock to final plant site Alaska North Slope
- This North Slope Alaska estimate excludes certain scope, to be estimated by others, as follows:
    - Outside Battery Limits (OSBL) scope
- This North Slope Alaska estimate excludes certain scope, assumed to be acceptable, as follows:
    - Bathometric requirements or Dredging
    - Dock modifications

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00
All-In NS Sub Contractor Craft Wage Rate $300.00

SUMMARY OVERALL L48 & NS ALL SCOPE

ACCT	DESCRIPTION	L48 MOD YARD WORKHOURS	NS FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	TOTAL	% of DFC	% of TIC
01	DEMOLITION							NOT INCLUDED		
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK						$20,539,763	$20,539,763	2.0%	0.8%
04	CONCRETE									
05	STRUCTURES	824,565		$49,473,919		$92,717,166		$142,191,085	13.6%	5.4%
06	PERMANENT PLANT EQUIPMENT	1,137,258		$58,094,661		**$227,267,956**		$285,362,617	27.3%	10.8%
11	PIPING	2,338,285		$140,297,109		$80,795,365		$221,092,474	21.1%	8.4%
12	ELECTRICAL	211,795		$12,707,752		$10,924,282		$23,632,034	2.3%	0.9%
13	INSTRUMENTATION & CONTROLS	54,667		$3,280,041		$4,599,910		$7,879,951	0.8%	0.3%
14	PAINTING / COATING / LINING	119,025		$7,141,506		$217,915		$7,359,421	0.7%	0.3%
15	INSULATION	344,462		$20,667,701		$6,200,291		$26,867,992	2.6%	1.0%
16	BLDGS/OFFSITES	13,924		$835,465		$993,222		$1,828,687	0.2%	0.1%
	Module Setting, Interconnecting, & Elect. - North Slope Alaska		1,034,091		$310,227,318			$310,227,318	29.6%	11.8%
	DIRECT FIELD COST	**5,043,980**	**1,034,090**	**$292,498,000**	**$310,227,000**	**$423,716,000**	**$20,540,000**	**$1,046,981,000**	100%	39.7%
									4.61	
31	THIRD PARTY CM (AT MODULE FAB YARD)	504,400		$40,352,000				$40,352,000		1.5%
32	THIRD PARTY CM (AT NORTH SLOPE SITE)		103,410	$36,194,000				$36,194,000		1.4%
33	TEMPORARY FACILITIES							Included w/Directs		
41	CONSTR EQUIP, TOOLS, SUPPLIES							Included w/Directs		
42	SMALL TOOLS & CONSUMABLES							Included w/Directs		
49	CONSTRUCTION CAMP (Included in Rate)							Included w/Directs		
51	STARTUP CRAFT SUPPORT ALLOWANCE			$6,722,000				$6,722,000		0.3%
	INDIRECT FIELD COST	504,400	103,410	$83,268,000				**$83,268,000**		3.2%
	TOTAL FIELD COST	**5,548,400**	**1,137,500**	**$375,766,000**	**$310,227,000**	**$423,716,000**	**$20,540,000**	**$1,130,249,000**		42.9%
61	ENGINEERING (HOME OFFICE)						$422,400,000			
	TOTAL HOME OFFICE							**$422,400,000**		16.0%
	TOTAL FIELD AND HOME OFFICE							**$1,552,649,000**		58.9%
71	INSURANCE (CGL)		1.00% on TIC					$26,400,000		1.0%
71	BONDS							NOT INCLUDED		
71	BUILDING PERMITS							NOT INCLUDED		
71	TAXES		5.00% allowance on total material					$21,186,000		0.8%
51	First Fills, Capital Spares & Vendor Reps		20.00% allowance on total equipment material					$45,454,000		1.7%
73	Warranty/Guarantee							NOT INCLUDED		
32	Craft Premium Pay							INCLUDED IN DIRECT WAGE RATE		
22	FREIGHT (**Not Incl.** Modules to port & ocean transport)		8.00% on total material plus Equip in S/C					$33,897,000		
92	CONTINGENCY		20.00% on all above costs					$335,917,000		
94	ESCALATION		Future Escalation Excluded					NOT INCLUDED		
	MODULE TRANSPORTATION ALLOWANCE (From L48 fab yard to dock, barge from L48 to NS & NS dock to site)							$622,224,000		23.6%
	Total Installed Cost (TIC)							**$2,637,727,000**	**11.61**	100.0%
99	PROJECT FEE		12.00% **on all Above Costs**					$316,527,000		12.0%
	EPC TOTAL							**$2,954,254,000**	**13.00**	112.0%
	CO2 Gas Compression NS Modular TIC - Common (Scaled from case 7a/11a USGC Stick built)							$491,700,000		
	CO2 Dehydration NS Modular TIC - Common (Scaled from case 12a alt 1 USGC Stick built)							$185,800,000		
	GRAND TOTAL							**$3,631,754,000**	**15.98**	138%

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS
Labor Factor L48: 1.00
All-In L48 Sub Contractor Craft Wage Rate: $60.00
All-In NS Sub Contractor Craft Wage Rate: $300.00

SUMMARY OVERALL L48 MOD YARD ONLY

ACCT	DESCRIPTION	L48 MOD YARD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	TOTAL	% of DFC	% of TIC
01	DEMOLITION						NOT INCLUDED		
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK								
04	CONCRETE								
05	STRUCTURES	824,565	$49,473,919		$92,717,166		$142,191,085	19.9%	
06	PERMANENT PLANT EQUIPMENT	1,137,258	$58,094,661		**$227,267,956**		$285,362,617	39.8%	
11	PIPING	2,338,285	$140,297,109		$80,795,365		$221,092,474	30.9%	
12	ELECTRICAL	211,795	$12,707,752		$10,924,282		$23,632,034	3.3%	
13	INSTRUMENTATION & CONTROLS	54,667	$3,280,041		$4,599,910		$7,879,951	1.1%	
14	PAINTING / COATING / LINING	119,025	$7,141,506		$217,915		$7,359,421	1.0%	
15	INSULATION	344,462	$20,667,701		$6,200,291		$26,867,992	3.8%	
16	BLDGS/OFFSITES	13,924	$835,465		$993,222		$1,828,687	0.3%	
	Module Setting, Interconnecting, & Elect. - North Slope Alaska								
	DIRECT FIELD COST	**5,043,980**	**$292,498,000**		**$423,716,000**		**$716,214,000**	100%	
								3.15	
31	THIRD PARTY CM (AT MODULE FAB YARD)	504,400	$40,352,000				$40,352,000		
32	THIRD PARTY CM (AT NORTH SLOPE SITE)								
33	TEMPORARY FACILITIES						Included w/Directs		
41	CONSTR EQUIP, TOOLS, SUPPLIES						Included w/Directs		
42	SMALL TOOLS & CONSUMABLES						Included w/Directs		
49	CONSTRUCTION CAMP (Included in Rate)						Included w/Directs		
51	STARTUP CRAFT SUPPORT ALLOWANCE		$6,722,000				$6,722,000		
	INDIRECT FIELD COST	504,400	$47,074,000				**$47,074,000**		
	TOTAL FIELD COST	**5,548,400**	**$339,572,000**		**$423,716,000**		**$763,288,000**		

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

SUMMARY OVERALL NS ONLY

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Labor Factor L48: 1.00
All-In L48 Sub Contractor Craft Wage Rate: $60.00
All-In NS Sub Contractor Craft Wage Rate: $300.00

ACCT	DESCRIPTION	NS FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	TOTAL	% of DFC	% of TIC
01	DEMOLITION						NOT INCLUDED		
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK					$20,539,763	$20,539,763	6.2%	
04	CONCRETE								
05	STRUCTURES								
06	PERMANENT PLANT EQUIPMENT								
11	PIPING								
12	ELECTRICAL								
13	INSTRUMENTATION & CONTROLS								
14	PAINTING / COATING / LINING								
15	INSULATION								
16	BLDGS/OFFSITES								
	Module Setting, Interconnecting, & Elect. - North Slope Alaska	1,034,091		$310,227,318			$310,227,318	93.8%	
	DIRECT FIELD COST	**1,034,090**		**$310,227,000**		**$20,540,000**	**$330,767,000**	100%	
31	THIRD PARTY CM (AT MODULE FAB YARD)								
32	THIRD PARTY CM (AT NORTH SLOPE SITE)	103,410	$36,194,000				$36,194,000		
33	TEMPORARY FACILITIES						Included w/Directs		
41	CONSTR EQUIP, TOOLS, SUPPLIES						Included w/Directs		
42	SMALL TOOLS & CONSUMABLES						Included w/Directs		
49	CONSTRUCTION CAMP (Included in Rate)						Included w/Directs		
51	STARTUP CRAFT SUPPORT ALLOWANCE								
	INDIRECT FIELD COST		$36,194,000				**$36,194,000**		
	TOTAL FIELD COST		**$36,194,000**	**$310,227,000**		**$20,540,000**	**$366,961,000**		

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

SUMMARY OVERALL L48 & NS Common & Train 1 ONLY

Labor Factor L48: 1.00
All-In L48 Sub Contractor Craft Wage Rate: $60.00
All-In NS Sub Contractor Craft Wage Rate: $300.00

ACCT	DESCRIPTION	L48 MOD YARD WORKHOURS	NS FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	TOTAL	% of DFC	% of TIC
01	DEMOLITION							NOT INCLUDED		
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK						$19,602,963	$19,602,963	4.0%	1.8%
04	CONCRETE									
05	STRUCTURES	681,655		$40,899,319		$76,311,696		$117,211,015	24.0%	10.9%
06	PERMANENT PLANT EQUIPMENT	640,718		$28,302,261		**$101,022,906**		$129,325,167	26.5%	12.1%
11	PIPING	662,685		$39,761,109		$27,424,635		$67,185,744	13.8%	6.3%
12	ELECTRICAL	117,715		$7,062,952		$7,654,872		$14,717,824	3.0%	1.4%
13	INSTRUMENTATION & CONTROLS	25,967		$1,558,041		$1,839,560		$3,397,601	0.7%	0.3%
14	PAINTING / COATING / LINING	109,225		$6,553,506		$168,665		$6,722,171	1.4%	0.6%
15	INSULATION	127,982		$7,678,901		$2,936,661		$10,615,562	2.2%	1.0%
16	BLDGS/OFFSITES	6,624		$397,465		$472,382		$869,847	0.2%	0.1%
	Module Setting, Interconnecting, & Elect. - North Slope Alaska		395,111		$118,533,218			$118,533,218	24.3%	11.1%
	DIRECT FIELD COST	**2,372,570**	**395,110**	**$132,214,000**	**$118,533,000**	**$217,831,000**	**$19,603,000**	**$488,181,000**	100%	45.5%
									4.83	
31	THIRD PARTY CM (AT MODULE FAB YARD)	237,260		$18,981,000				$18,981,000		1.8%
32	THIRD PARTY CM (AT NORTH SLOPE SITE)		19,760	$6,916,000				$6,916,000		0.7%
33	TEMPORARY FACILITIES							Included w/Directs		
41	CONSTR EQUIP, TOOLS, SUPPLIES							Included w/Directs		
42	SMALL TOOLS & CONSUMABLES							Included w/Directs		
49	CONSTRUCTION CAMP (Included in Rate)							Included w/Directs		
51	STARTUP CRAFT SUPPORT ALLOWANCE			$3,162,000				$3,162,000		0.3%
	INDIRECT FIELD COST	237,260	19,760	$29,059,000				**$29,059,000**		2.7%
	TOTAL FIELD COST	**2,609,800**	**414,900**	**$161,273,000**	**$118,533,000**	**$217,831,000**	**$19,603,000**	**$517,240,000**		48.2%
61	ENGINEERING (HOME OFFICE)						$171,200,000			
	TOTAL HOME OFFICE							**$171,200,000**		16.0%
	TOTAL FIELD AND HOME OFFICE							**$688,440,000**		64.2%
71	INSURANCE (CGL)		1.00% on TIC					$10,700,000		1.0%
71	BONDS							NOT INCLUDED		
71	BUILDING PERMITS							NOT INCLUDED		
71	TAXES		5.00% allowance on total material					$10,892,000		1.0%
51	First Fills, Capital Spares & Vendor Reps		20.00% allowance on total equipment material					$20,205,000		1.9%
73	Warranty/Guarantee							NOT INCLUDED		
32	Craft Premium Pay							INCLUDED IN DIRECT WAGE RATE		
22	FREIGHT (**Not Incl.** Modules to port & ocean transport)		8.00% on total material plus Equip in S/C					$17,426,000		1.6%
92	CONTINGENCY		20.00% on all above costs					$149,533,000		
94	ESCALATION		Future Escalation Excluded					NOT INCLUDED		
	MODULE TRANSPORTATION ALLOWANCE (From L48 fab yard to dock, barge from L48 to NS & NS dock to site)							$174,938,000		16.3%
	Total Installed Cost (TIC)							**$1,072,134,000**	**10.61**	100.0%
99	PROJECT FEE		12.00% on all Above Costs on all Above Costs					$128,656,000		12.0%
	EPC TOTAL							**$1,200,790,000**	**11.89**	112.0%
	GRAND TOTAL							**$1,200,790,000**	**11.89**	112%

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS
Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00
All-In NS Sub Contractor Craft Wage Rate $300.00

SUMMARY OVERALL L48 Common & Train 1 ONLY

ACCT	DESCRIPTION	L48 MOD YARD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	% of DFC
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	681,655	$40,899,319		$76,311,696		$117,211,015	33.5%
06	PERMANENT PLANT EQUIPMENT	640,718	$28,302,261		**$101,022,906**		$129,325,167	37.0%
11	PIPING	662,685	$39,761,109		$27,424,635		$67,185,744	19.2%
12	ELECTRICAL	117,715	$7,062,952		$7,654,872		$14,717,824	4.2%
13	INSTRUMENTATION & CONTROLS	25,967	$1,558,041		$1,839,560		$3,397,601	1.0%
14	PAINTING / COATING / LINING	109,225	$6,553,506		$168,665		$6,722,171	1.9%
15	INSULATION	127,982	$7,678,901		$2,936,661		$10,615,562	3.0%
16	BLDGS/OFFSITES	6,624	$397,465		$472,382		$869,847	0.3%
	Module Setting, Interconnecting, & Elect. - North Slope Alaska							
	DIRECT FIELD COST	**2,372,570**	**$132,214,000**		**$217,831,000**		**$350,045,000**	100%
								3.47
31	THIRD PARTY CM (AT MODULE FAB YARD)	237,260	$18,981,000				$18,981,000	
32	THIRD PARTY CM (AT NORTH SLOPE SITE)							
33	TEMPORARY FACILITIES						Included w/Directs	
41	CONSTR EQUIP, TOOLS, SUPPLIES						Included w/Directs	
42	SMALL TOOLS & CONSUMABLES						Included w/Directs	
49	CONSTRUCTION CAMP (Included in Rate)						Included w/Directs	
51	STARTUP CRAFT SUPPORT ALLOWANCE		$3,162,000				$3,162,000	
	INDIRECT FIELD COST		$22,143,000				**$22,143,000**	
	TOTAL FIELD COST		**$154,357,000**		**$217,831,000**		**$372,188,000**	

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

SUMMARY OVERALL NS Common & Train 1 ONLY

Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00
All-In NS Sub Contractor Craft Wage Rate $300.00

ACCT	DESCRIPTION	NS FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	TOTAL	% of DFC	% of TIC
01	DEMOLITION						NOT INCLUDED		
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK					$19,602,963	$19,602,963	14.2%	#REF!
04	CONCRETE								#REF!
05	STRUCTURES								#REF!
06	PERMANENT PLANT EQUIPMENT								#REF!
11	PIPING								#REF!
12	ELECTRICAL								#REF!
13	INSTRUMENTATION & CONTROLS								#REF!
14	PAINTING / COATING / LINING								#REF!
15	INSULATION								#REF!
16	BLDGS/OFFSITES								#REF!
Module	Setting, Interconnecting, & Elect. - North Slope Alaska	395,111		$118,533,218			$118,533,218	85.8%	#REF!
									#REF!
	DIRECT FIELD COST	**395,110**		**$118,533,000**		**$19,603,000**	**$138,136,000**	100%	#REF!
								#DIV/0!	
31	THIRD PARTY CM (AT MODULE FAB YARD)								#REF!
32	THIRD PARTY CM (AT NORTH SLOPE SITE)	39,510	$13,829,000				$13,829,000		
33	TEMPORARY FACILITIES						Included w/Directs		
41	CONSTR EQUIP, TOOLS, SUPPLIES						Included w/Directs		
42	SMALL TOOLS & CONSUMABLES						Included w/Directs		
49	CONSTRUCTION CAMP (Included in Rate)						Included w/Directs		
51	STARTUP CRAFT SUPPORT ALLOWANCE								#REF!
	INDIRECT FIELD COST	39,510	$13,829,000				**$13,829,000**		#REF!
	TOTAL FIELD COST	**434,600**	**$13,829,000**	**$118,533,000**		**$19,603,000**	**$151,965,000**		#REF!

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Divisior   URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00
All-In NS Sub Contractor Craft Wage Rate $300.00

SUMMARY OVERALL L48 & NS DIRECT FIELD COST ONLY

ACCT	DESCRIPTION	L48 MOD YARD WORKHOURS	NS FIELD WORKHOURS	L48 MOD YARD LAB	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	TOTAL	
	Area 001 Flue Gas Blowers - Common L48	326,015		$19,560,913		$27,085,793		$46,646,706	
	Area 002 Flue Gas Quench - Train 1 L48	373,415		$22,404,915		$26,064,775		$48,469,690	3.42
	Area 003 CO2 Capture - Train 1 L48	434,195		$26,051,725		$36,177,458		$62,229,183	2.59
	Area 012 Ductwork & piperack scope add'l to equipment components (All Trains) L48	1,238,947		$64,196,002		$128,503,352		$192,699,354	2.59
	SUBTOTAL DIRECT FIELD COST COMMON & TRAIN 1 L48 MOD YARD ONLY	**2,372,572**		**$132,213,555**		**$217,831,378**		**$350,044,933**	
	Area 014 North Slope Earthwork VSMs & Gravel - Train 1 NS						$19,602,963	$19,602,963	
	NS Setting, Interconnecting Modules, & Elect - (Common & Trains 1) North Slope Alaska		395,111		$118,533,218			$118,533,218	
	SUBTOTAL DIRECT FIELD COST COMMON & TRAIN 1 NS ONLY		**395,111**		**$118,533,218**		**$19,602,963**	**$138,136,181**	
	Area 006 Flue Gas Quench - Train 2 (Scaled from train 1) L48	394,690		$23,681,400		$27,550,030		$51,231,430	3.42
	Area 007 CO2 Capture - Train 2 (Scaled from train 1) L48	458,930		$27,535,800		$38,238,980		$65,774,780	2.59
	Area 008 Flue Gas Quench - Train 3 (Scaled from train 1) L48	444,620		$26,677,200		$31,034,800		$57,712,000	3.42
	Area 009 CO2 Capture - Train 3 (Scaled from train 1) L48	516,990		$31,019,400		$43,075,760		$74,095,160	2.59
	Area 010 Flue Gas Quench - Train 4 (Scaled from train 1) L48	395,880		$23,752,800		$27,632,170		$51,384,970	3.42
	Area 011 CO2 Capture - Train 4 (Scaled from train 1) L48	460,300		$27,618,000		$38,352,990		$65,970,990	2.59
	SUBTOTAL DIRECT FIELD COST TRAIN2 2, 3, 4 L48 MOD YARD ONLY	**2,671,410**		**$160,284,600**		**$205,884,730**		**$366,169,330**	
	Area 015 North Slope Earthwork VSMs & Gravel - (Trains 2-4 Scaled from Train 1) NS						$936,800	$936,800	
	NS Setting, Interconnecting Modules, & Elect - (Trains 2 -4) North Slope Alaska		638,980		$191,694,100			$191,694,100	
	SUBTOTAL DIRECT FIELD COST TRAIN2 2, 3, 4 NS ONLY		**638,980**		**$191,694,100**		**$936,800**	**$192,630,900**	
	CO2 Gas Compression NS Modular TIC - Common (Scaled from case 7a/11a USGC Stick built)			Scaled TIC values only on summary Sheet					
	CO2 Dehydration NS Modular TIC - Common (Scaled from case 12a alt 1 USGC Stick built)			Scaled TIC values only on summary Sheet					
	SUBTOTAL DIRECT FIELD COST	**5,043,982**	**1,034,091**	**$292,498,155**	**$310,227,318**	**$423,716,108**	**$20,539,763**	**$1,046,981,344**	

CLIENT:
PROJECT: TransCanada CO2 Capture Study
LOCATION: Alaska
JOB NO.: 29869
REV NO.:

URS Washington Division

Tag No	Component Name	Equip Category	Equip Type	Equip Description	Quantity	Equip Matl	Equip Weight	Wgt Unit
Area 001 Flue Gas Blowers - Common L48								
4001FN0101	Prop Cmpr Tur Flu Gas Blw	Compressors	Fans	Centrifugal fan	4	$789,200	42,400	LBS
4001FN0102	Sale Cmpr Tur Flu Gas Blw	Compressors	Fans	Centrifugal fan	30	$6,537,000	375,000	LBS
5001FN0101	CO2 Cmpr Tur Flu Gas Blw	Compressors	Fans	Centrifugal fan	21	$4,575,900	262,500	LBS
9061FN0101	Generator Tur Flu Gas Blw	Compressors	Fans	Centrifugal fan	12	$2,614,800	150,000	LBS
				Process Ductwork		$4,968,673	2,828,508	LBS
						$19,485,573		
Area 002 Flue Gas Quench - Train 1 L48								
9501ACLR010:	DCC Circ Water Clr +Winte	Exchangers	Heat Exchangers	Air cooler, free-standing or rack-mounted	1	$11,008,262	2,764,800	LBS
9501C0101	Flue Gas Dir Cntct Cooler	Vessels	Vertical Tanks	Vertical process vessel	1	$1,621,600	618,300	LBS
9501FLT0101	DCC Circ. Water Filter	Separation	Filters	Cartridge filter (5 micron cotton)	3	$120,600	3,300	LBS
9501P0101A/B	DCC Circ Water Pump	Pumps	Centrifugal Pumps	API 610 pump	2	$1,417,000	39,600	LBS
						$14,167,462		
Area 003 CO2 Capture - Train 1 L48								
9601A0101	CO2 Cap Antifoam Inj Pack	Pumps	Centrifugal Pumps	API 610 pump	1	$181,000	470	LBS
9601A0102	Amine Reclaimer	Exchangers	Reboilers	Kettle type reboiler with floating head	1	$467,800	55,600	LBS
9601ACLR010:	CO2 Cap Lean Solv Clr +Wn	Exchangers	Heat Exchangers	Air cooler, free-standing or rack-mounted	1	$528,276	165,300	LBS
9601ACLR010:	CO2 Cap SmiLn Slv Clr +Wn	Exchangers	Heat Exchangers	Air cooler, free-standing or rack-mounted	1	$1,882,148	387,200	LBS
9601ACLR010:	CO2 Cap Regen Cndnsr +Wnt	Exchangers	Heat Exchangers	Air cooler, free-standing or rack-mounted	1	$2,086,497	510,000	LBS
9601C0101	CO2 Cap Abs wFP HC 2Y	Vessels	Vertical Tanks	Vertical process vessel	1	$5,291,600	600,800	LBS
9601C0102	CO2 Cap Regen wFP HC 2Y	Towers	Towers	Packed tower	1	$4,361,100	404,500	LBS
9601FLT0101	CO2 Capture Solv Filter	Separation	Filters	Cartridge filter (5 micron cotton)	1	$39,600	980	LBS
9601FLT0102	CO2 Cap Act Carbon Filter	Towers	Towers	Packed tower	1	$158,100	16,600	LBS
9601FLT0103	CO2 Cap Act-C Out Filter	Separation	Filters	Cartridge filter (5 micron cotton)	1	$33,300	390	LBS
9601FLT0104	CO2 Cap Solv Sump Filter	Separation	Filters	Cartridge filter (5 micron cotton)	1	$15,400	160	LBS
9601HX0101	CO2 Cap Lean/Rich Exch	Exchangers	Heat Exchangers	Fixed tube sheet shell and tube exchanger	1	$1,477,300	223,500	LBS
9601HX0102	CO2 Cap SemiLean/Rich Ex	Exchangers	Heat Exchangers	Fixed tube sheet shell and tube exchanger	1	$1,946,000	296,000	LBS
9601HX0103	CO2 Capture Reboiler	Exchangers	Heat Exchangers	Fixed tube sheet shell and tube exchanger	1	$3,347,100	566,800	LBS
9601P0101A/B	CO2 Cap Lean Solvent Pump	Pumps	Centrifugal Pumps	API 610 pump	2	$185,600	6,600	LBS
9601P0102A/B	CO2 Cap Lean Slv Bst Pump	Pumps	Centrifugal Pumps	API 610 pump	2	$199,400	6,200	LBS
9601P0103A/B	CO2 Cap Rich Solvent Pump	Pumps	Centrifugal Pumps	API 610 pump	2	$478,000	14,000	LBS
9601P0104A/B	CO2 Cap Water Wash Pump	Pumps	Centrifugal Pumps	API 610 pump	2	$231,000	7,000	LBS
9601P0105A/B	CO2 Capture Reflux Pump	Pumps	Centrifugal Pumps	API 610 pump	2	$83,600	2,000	LBS
9601P0106A/B	CO2 Cap SemiLean Slv Pump	Pumps	Centrifugal Pumps	API 610 pump	2	$354,800	11,000	LBS
9601P0107	CO2 Cap Pure Slv Tfr Pump	Pumps	Centrifugal Pumps	API 610 pump	1	$26,700	570	LBS
9601P0108	CO2 Cap Solvent Sump Pump	Pumps	Centrifugal Pumps	Vertical sump pump - turbine impeller	1	$3,200	380	LBS
9601TK0101	CO2 Cap Solv Invent Tank	Vessels	Vertical Tanks	Flat bottom storage tank, optional roof	1	$198,600	80,900	LBS
9601TK0102	CO2 Cap Solv Storage Tank	Vessels	Vertical Tanks	Flat bottom storage tank, optional roof	1	$89,400	27,200	LBS
9601V0101	CO2 Capture Reflux Drum	Vessels	Vertical Tanks	Vertical process vessel	1	$271,400	21,700	LBS
9601V0102	CO2 Capture Solvent Sump	Vessels	Horizontal Tanks	Horizontal drum	1	$61,500	6,800	LBS
						$23,998,421		
#REF!								
DW-1	Ductwork	Cost Known Compor	Miscellaneous	Cost Known Component (EQP)		43,371,450		LBS
				Total Equipment from Equipment List	**106**	**$101,022,906**	**10,497,058**	
				Area 006 Flue Gas Quench - Train 2 (Scaled from train 1) L48		$14,974,770		
				Area 007 CO2 Capture - Train 2 (Scaled from train 1) L48		$25,365,930		
				Area 008 Flue Gas Quench - Train 3 (Scaled from train 1) L48		$16,868,910		
				Area 009 CO2 Capture - Train 3 (Scaled from train 1) L48		$28,574,440		
				Area 010 Flue Gas Quench - Train 4 (Scaled from train 1) L48		$15,019,430		
				Area 011 CO2 Capture - Train 4 (Scaled from train 1) L48		$25,441,570		
				Area 014 North Slope Earthwork VSMs & Gravel - Train 1 NS		$0		
				Area 015 North Slope Earthwork VSMs & Gravel - (Trains 2-4 Scaled from Train 1) NS		$0		
				Grand Total All Equipment Material	**106**	**$227,267,956**		

Weight of Equip vs. Total Weight											
CO2 Capture Study Modules											
								Sizes of Modules in Kbase			
Area	**Equip Qty**	**Wt. / Qty**	**Equip Weight**	**Total Module Weight**	**% of Equip wt to tot**			L	W	H	Total CF
CO2 Capture	32	106,645	3,412,650	6,814,755	50.4%			100	40	50	200,000
Flue Gas Blowers	67	54,603	3658408	6,737,606	12.3%			100	40	50	200,000
Flue Gas Quench	7	489,429	3,426,000	6,200,933	55.2%			100	40	50	200,000
piperack				20,548,851	0.0%			100	40	50	200,000
	106		**7,713,750**	**40,302,145**							**800,000**
DW Support				9,680,000	59.3%			100	40	50	200,000
Totals			57,047,100	128,637,000							1,800,000
								typ.			
TOTAL Equip wt. vs. Module wt.	without DW & Support				26.4%			29			
TOTAL Lbs / CF					37			5.4			
TOTAL Hours / Ton					88			89			

CLIENT: TransCanada
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Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 001 Flue Gas Blowers - Common L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	38,268	$2,296,054		$4,866,650		$7,162,704	
06	PERMANENT PLANT EQUIPMENT	198,931	$11,935,854		**$19,485,573**		$31,421,427	
11	PIPING	36,510	$2,190,589		$265,547		$2,456,135	
12	ELECTRICAL	22,911	$1,374,633		$1,531,220		$2,905,852	
13	INSTRUMENTATION & CONTROLS	17,010	$1,020,628		$632,779		$1,653,407	
14	PAINTING / COATING / LINING	1,266	$75,963		$2,958		$78,921	
15	INSULATION	8,912	$534,705		$143,606		$678,311	
16	BLDGS/OFFSITES	2,208	$132,488		$157,461		$289,949	
	DIRECT FIELD COST	**326,015**	**$19,560,913**		**$27,085,793**		**$46,646,706**	

CLIENT: TransCanada
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REV NO.:

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DATE: 28-May-09
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Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 002 Flue Gas Quench - Train 1 L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	20,214	$1,212,860		$2,385,727		$3,598,586	
06	PERMANENT PLANT EQUIPMENT	34,146	$2,048,786		**$14,167,462**		$16,216,248	
11	PIPING	276,290	$16,577,419		$8,395,072		$24,972,490	
12	ELECTRICAL	15,755	$945,298		$486,308		$1,431,607	
13	INSTRUMENTATION & CONTROLS	1,336	$80,134		$183,649		$263,783	
14	PAINTING / COATING / LINING	819	$49,150		$4,813		$53,963	
15	INSULATION	23,750	$1,425,024		$363,014		$1,788,038	
16	BLDGS/OFFSITES	1,104	$66,244		$78,730		$144,975	
	DIRECT FIELD COST	**373,415**	**$22,404,915**		**$26,064,775**		**$48,469,689**	3.42

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Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 003 CO2 Capture - Train 1 L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	22,990	$1,379,390		$2,573,905		$3,953,295	
06	PERMANENT PLANT EQUIPMENT	115,965	$6,957,923		**$23,998,421**		$30,956,344	
11	PIPING	230,273	$13,816,388		$7,739,750		$21,556,137	
12	ELECTRICAL	12,688	$761,309		$502,086		$1,263,396	
13	INSTRUMENTATION & CONTROLS	7,338	$440,307		$650,849		$1,091,156	
14	PAINTING / COATING / LINING	2,141	$128,432		$10,078		$138,510	
15	INSULATION	41,696	$2,501,733		$623,638		$3,125,371	
16	BLDGS/OFFSITES	1,104	$66,244		$78,730		$144,975	
	DIRECT FIELD COST	**434,195**	**$26,051,725**		**$36,177,458**		**$62,229,183**	2.59

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Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 012 Ductwork & piperack scope add'l to equipment components (All Trains) L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	600,184	$36,011,016		$66,485,414		$102,496,430	
06	PERMANENT PLANT EQUIPMENT	291,675	$7,359,699		**$43,371,450**		$50,731,149	
11	PIPING	119,612	$7,176,714		$11,024,267		$18,200,981	
12	ELECTRICAL	66,362	$3,981,712		$5,135,258		$9,116,970	
13	INSTRUMENTATION & CONTROLS	283	$16,973		$372,284		$389,256	
14	PAINTING / COATING / LINING	104,999	$6,299,961		$150,816		$6,450,777	
15	INSULATION	53,624	$3,217,440		$1,806,403		$5,023,843	
16	BLDGS/OFFSITES	2,208	$132,488		$157,461		$289,949	
	DIRECT FIELD COST	**1,238,947**	**$64,196,002**		**$128,503,352**		**$192,699,354**	4.44

CLIENT: TransCanada
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Area 014 North Slope Earthwork VSMs & Gravel - Train 1 NS

All-In NS Sub Contractor Craft Wage Rate $300.00

ACCT	DESCRIPTION	NS FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**
01	DEMOLITION						NOT INCLUDED
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK					$19,602,963	$19,602,963
04	CONCRETE						
05	STRUCTURES	395,111		$118,533,218			$118,533,218
06	PERMANENT PLANT EQUIPMENT						
11	PIPING						
12	ELECTRICAL						
13	INSTRUMENTATION & CONTROLS						
14	PAINTING / COATING / LINING						
15	INSULATION						
16	BLDGS/OFFSITES						
	DIRECT FIELD COST	395,111		**$118,533,218**		**$19,602,963**	**$138,136,181**

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
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Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 006 Flue Gas Quench - Train 2 (Scaled from train 1) L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	21,370	$1,282,200		$2,521,670		$3,803,870	
06	PERMANENT PLANT EQUIPMENT	36,090	$2,165,400		**$14,974,770**		$17,140,170	
11	PIPING	292,030	$17,521,800		$8,873,450		$26,395,250	
12	ELECTRICAL	16,650	$999,000		$514,020		$1,513,020	
13	INSTRUMENTATION & CONTROLS	1,410	$84,600		$194,110		$278,710	
14	PAINTING / COATING / LINING	870	$52,200		$5,090		$57,290	
15	INSULATION	25,100	$1,506,000		$383,700		$1,889,700	
16	BLDGS/OFFSITES	1,170	$70,200		$83,220		$153,420	
	DIRECT FIELD COST	**394,690**	**$23,681,400**		**$27,550,030**		**$51,231,430**	3.42

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
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Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 007 CO2 Capture - Train 2 (Scaled from train 1) L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	24,300	$1,458,000		$2,720,580		$4,178,580	
06	PERMANENT PLANT EQUIPMENT	122,570	$7,354,200		**$25,365,930**		$32,720,130	
11	PIPING	243,390	$14,603,400		$8,180,790		$22,784,190	
12	ELECTRICAL	13,410	$804,600		$530,700		$1,335,300	
13	INSTRUMENTATION & CONTROLS	7,760	$465,600		$687,940		$1,153,540	
14	PAINTING / COATING / LINING	2,260	$135,600		$10,650		$146,250	
15	INSULATION	44,070	$2,644,200		$659,170		$3,303,370	
16	BLDGS/OFFSITES	1,170	$70,200		$83,220		$153,420	
	DIRECT FIELD COST	**458,930**	**$27,535,800**		**$38,238,980**		**$65,774,780**	2.59

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS
Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 008 Flue Gas Quench - Train 3 (Scaled from train 1) L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	24,070	$1,444,200		$2,840,640		$4,284,840	
06	PERMANENT PLANT EQUIPMENT	40,660	$2,439,600		**$16,868,910**		$19,308,510	
11	PIPING	328,970	$19,738,200		$9,995,840		$29,734,040	
12	ELECTRICAL	18,760	$1,125,600		$579,040		$1,704,640	
13	INSTRUMENTATION & CONTROLS	1,590	$95,400		$218,670		$314,070	
14	PAINTING / COATING / LINING	980	$58,800		$5,730		$64,530	
15	INSULATION	28,280	$1,696,800		$432,230		$2,129,030	
16	BLDGS/OFFSITES	1,310	$78,600		$93,740		$172,340	
	DIRECT FIELD COST	**444,620**	**$26,677,200**		**$31,034,800**		**$57,712,000**	3.42

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 009 CO2 Capture - Train 3 (Scaled from train 1) L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	27,370	$1,642,200		$3,064,700		$4,706,900	
06	PERMANENT PLANT EQUIPMENT	138,080	$8,284,800		**$28,574,440**		$36,859,240	
11	PIPING	274,180	$16,450,800		$9,215,560		$25,666,360	
12	ELECTRICAL	15,110	$906,600		$597,820		$1,504,420	
13	INSTRUMENTATION & CONTROLS	8,740	$524,400		$774,950		$1,299,350	
14	PAINTING / COATING / LINING	2,550	$153,000		$12,000		$165,000	
15	INSULATION	49,650	$2,979,000		$742,550		$3,721,550	
16	BLDGS/OFFSITES	1,310	$78,600		$93,740		$172,340	
	DIRECT FIELD COST	**516,990**	**$31,019,400**		**$43,075,760**		**$74,095,160**	2.59

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS
Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 010 Flue Gas Quench - Train 4 (Scaled from train 1) L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	21,430	$1,285,800		$2,529,190		$3,814,990	
06	PERMANENT PLANT EQUIPMENT	36,200	$2,172,000		**$15,019,430**		$17,191,430	
11	PIPING	292,910	$17,574,600		$8,899,910		$26,474,510	
12	ELECTRICAL	16,700	$1,002,000		$515,550		$1,517,550	
13	INSTRUMENTATION & CONTROLS	1,420	$85,200		$194,690		$279,890	
14	PAINTING / COATING / LINING	870	$52,200		$5,100		$57,300	
15	INSULATION	25,180	$1,510,800		$384,840		$1,895,640	
16	BLDGS/OFFSITES	1,170	$70,200		$83,460		$153,660	
	DIRECT FIELD COST	**395,880**	**$23,752,800**		**$27,632,170**		**$51,384,970**	3.42

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Labor Factor L48 1.00
All-In L48 Sub Contractor Craft Wage Rate $60.00

Area 011 CO2 Capture - Train 4 (Scaled from train 1) L48

ACCT	DESCRIPTION	FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**	
01	DEMOLITION						NOT INCLUDED	
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK							
04	CONCRETE							
05	STRUCTURES	24,370	$1,462,200		$2,728,690		$4,190,890	
06	PERMANENT PLANT EQUIPMENT	122,940	$7,376,400		**$25,441,570**		$32,817,970	
11	PIPING	244,120	$14,647,200		$8,205,180		$22,852,380	
12	ELECTRICAL	13,450	$807,000		$532,280		$1,339,280	
13	INSTRUMENTATION & CONTROLS	7,780	$466,800		$689,990		$1,156,790	
14	PAINTING / COATING / LINING	2,270	$136,200		$10,680		$146,880	
15	INSULATION	44,200	$2,652,000		$661,140		$3,313,140	
16	BLDGS/OFFSITES	1,170	$70,200		$83,460		$153,660	
	DIRECT FIELD COST	**460,300**	**$27,618,000**		**$38,352,990**		**$65,970,990**	2.59

CLIENT: TransCanada
PROJECT: Class V Estimate - CO2 Capture Study
LOCATION: North Slope Alaska
JOB NO.: 29869-003
REV NO.:

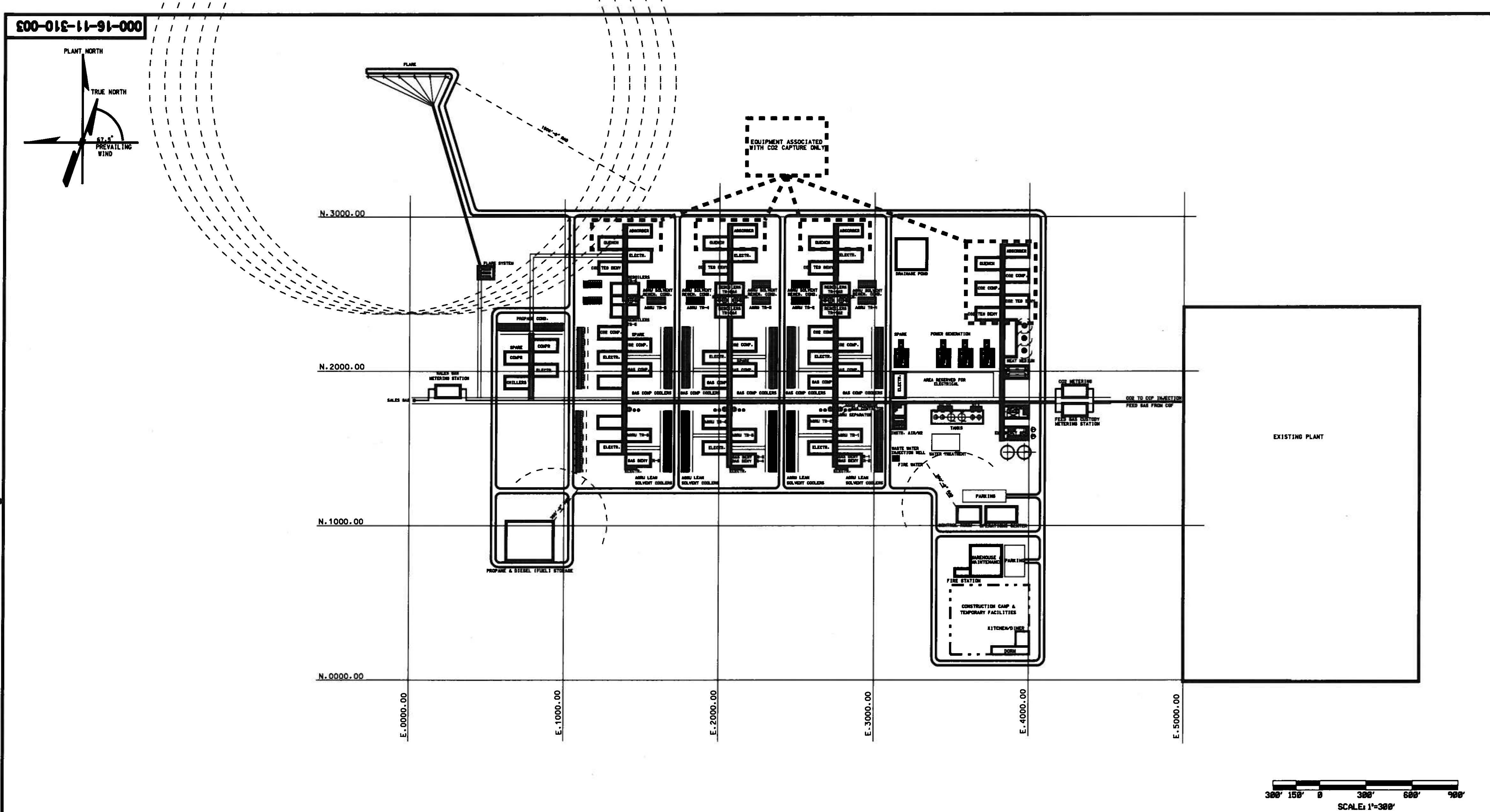
URS Washington Division

DATE: 28-May-09
PREPARED BY: RAS

Area 015 North Slope Earthwork VSMs & Gravel - (Trains 2-4 Scaled from Train 1) NS

All-In NS Sub Contractor Craft Wage Rate $300.00

ACCT	DESCRIPTION	NS FIELD WORKHOURS	L48 MOD YARD LABOR	NS FIELD LABOR	MATERIAL	SPECIALTY SUBCONTRACTORS	**TOTAL**
01	DEMOLITION						NOT INCLUDED
02 - 03	IMPROVEMENTS TO SITE / EARTHWORK					$936,800	$936,800
04	CONCRETE						
05	STRUCTURES	638,980		$191,694,100			$191,694,100
06	PERMANENT PLANT EQUIPMENT						
11	PIPING						
12	ELECTRICAL						
13	INSTRUMENTATION & CONTROLS						
14	PAINTING / COATING / LINING						
15	INSULATION						
16	BLDGS/OFFSITES						
	DIRECT FIELD COST	**638,980**		**$191,694,100**		**$936,800**	**$192,630,900**



ALASKA GAS TREATMENT PLANT SITE PLOT PLAN FOR CO2 CAPTURE STUDY

REVISION APPROVAL RECORD						REV	BY	DATE	REVISIONS	BY	CHKD
DISCIPLINE	BY	DATE	DISCIPLINE	BY	DATE						
ARCH.			MECHANICAL								
CIVIL			NUCLEAR								
ELECTRICAL			PIPING								
ENVIRON.			PROCESS								
GEN. ARRANG.			QA / QC								
HVAC			STRUCTURAL								
I & C											

DRAWING STATUS				
ISSUED	REV	DATE	SIGN	PEN
PRELIMINARY				
APPROVED FOR CONSTRUCTION				

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REV. NO.

PROJECT NO.: 29869

DRAWN: DATE:

CHECKED: DATE:

SCALE: 1"=300'-0"

TransCanada
In business to deliver

GAS TREATMENT PLANT
PRUDHOE BAY, ALASKA

URS
Washington Division

7800 E. UNION AVE., SUITE 100
DENVER, CO 80237
(303) 843-2000

Washington Group International, Inc. dba Washington Division of URS Corporation

DWG. NO. 000-16-11-310-003

REV

Texas Commission on Environmental Quality
Air Permits Division

New Source Review (NSR) Emission Calculations

This information is maintained by the Chemical NSR Section and is subject to change. Last update was made **January 2008**. These emission calculations represent current NSR guidelines and are provided for informational purposes only. The emission calculations are subject to change based on TCEQ case by case evaluation. Please contact the appropriate Chemical NSR Section management if there are questions related to the emission calculations.

Vapor Oxidizers

The methods used to determine emissions from oxidizers are very similar to those in the flare examples, but the emission factors used are different. Because the calculation methods are the same as those used in the flare examples, they will not be duplicated here. (Flare Calculations)

Hourly emissions are based on the maximum expected hourly emission rate during routine operations (does not include startups, shutdowns, or upsets), while the annual emissions are based on the annual operating rate. The preferred methods and emission factors for each type of air contaminant are described in the following paragraphs.

VOC. Calculate the emissions based on the waste gas to the oxidizer and the control efficiency (if a large amount of assist fuel is used, the EPA AP-42 natural gas boiler VOC emission factor may be used to determine VOC due to the incomplete combustion of natural gas). The exhaust molar flow rate and the maximum ppmv and VOC molecular weight should be used if BACT review is based on the outlet concentration.

SO_2. Assume 100 percent of the sulfur present in the waste and assist gas is oxidized to SO_2.

Halogens. Assume 100 percent conversion to corresponding acid. If more than a small fraction of halogen is expected in the waste gas being treated, a vendor estimate should be used to determine fraction of acid and gas (HCl and Cl_2, for example).

Products of Combustion. CO, NO_x, and particulate emissions should be determined based on vendor estimates if the information is available. The NO_x emissions are generally expected to be less than 0.10 lb/MMBtu (0.06 lb/MMBtu if firing rate greater than 40 MMBtu/hr), and CO exhaust concentrations are generally less than 100 ppmv. The applicant will need to provide the calculation basis for any NO_x emission expected as a result of nitrogen found in the VOC being combusted.

Particulate Matter. Particulate emissions are expected to be similar to those from gas fired boilers, and the appropriate factor from AP-42 may be used to estimate emissions.