

## FEASIBILITY STUDY

# Evaluation of Technical and Economic Parameters of Natural Gas Delivery Using Compressed Natural Gas (CNG) Technologies

## PHASE 2

### Fuel Delivery To A Community

Prepared for  
**QUEST Nova Scotia**

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**Jenmar Concepts**  
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## PREFACE

QUEST – Quality Urban Energy Systems of Tomorrow – is a national non-profit organization advancing education and research for integrated energy systems (linking energy with land-use, buildings, transportation, waste, water and wastewater at a community, neighbourhood or site level) to develop and support sustainable communities in Canada and is committed to making integrated community energy solutions (ICES) the new standard for land-use and transportation planning and development. QUEST works actively across Canada with its Caucuses. QUEST Caucuses provide a collaborative forum for organizations interested in approaching and managing energy challenges and opportunities in a manner consistent with QUEST’s principles, mission and vision.

A QUEST Nova Scotia Caucus was formed in 2010, and includes the following organizations: The Province of Nova Scotia, Efficiency Nova Scotia, Heritage Gas, Dalhousie University, Eco Efficiency Centre, Ecology Action Centre, Clean Nova Scotia, Halifax Regional Municipality, Union of Nova Scotia Municipalities, Clayton Developments, Eastport Developments, Cape Breton Municipality (CBRM), Nova Scotia Community College, Nova Scotia Agricultural College, Green Power Labs, The Construction Association of Nova Scotia, Atlantic Chapter Green Building Council, Canadian District Energy Association, AltaGas, Heritage Gas, Natural Gas Vehicle Association, and the Canadian Gas Association.

The Nova Scotia Department of Energy recently contributed funds to QUEST to investigate ways to advance sustainable transportation in the province; and the economics and supply/demand potential for using compressed natural gas in vehicles in the province and to supply businesses and communities not connected to the natural gas grid. Two working groups were created to explore each of these topics, and membership was drawn from the QUEST Nova Scotia Caucus along with suggestions of other appropriate organizations.

This applied research study entitled Evaluation of Technical and Economic Parameters of Natural Gas Delivery Using Compressed Natural Gas (CNG) Technologies Phase 1 and Phase 2 was commissioned by QUEST Nova Scotia to explore CNG infrastructure development scenarios. The study evaluates the conditions and combination of different parameters that would make the delivery of CNG to Nova Scotia communities economically feasible.

### **Acknowledgements**

We would like to acknowledge the extensive contribution, guidance and advice of the CNG Off Grid Steering members representing the Nova Scotia Department of Energy, Heritage Gas, Enbridge Gas, Stantec, Halifax Regional Municipality and the Canadian Gas Association.

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## EXECUTIVE SUMMARY

Phase 2 of the “Evaluation of Technical and Economic Parameters of Natural Gas Delivery Using Compressed Natural Gas (CNG) Technologies” study considers the supply of natural gas to an off-grid community of multiple industrial/commercial consumers. For the purpose of the study, average total annual consumption by the community is given as 350,000 GJ. The travel distance is increased to a 150 km round trip.

The study represents a scaled up model in relation to Phase 1 in that gas continues to be delivered by road transport from a single source to a single off-loading location; however, the addition of a local community distribution system delivers the fuel to a number of users with smaller loads.

The higher aggregate load volumes introduce the requirement for larger compression capacity and decanting equipment in addition to the local delivery infrastructure.

The load size of the user community required compression capacity (with 100% redundancy) of 2 units of 150 HP compressors and a pressure reduction system (PRS) sized for peak flows of 1458 GJ/day or 930 scfm (standard cubic feet per minute). Three units of transport trailers with a capacity of 300,900 scf are required due to the increased travel distance and load vis-à-vis Phase 1.

Jenmar Concepts' opinion of total probable capital investment for the project including mother station, mobile transport trailers, de-canting facility and community gas distribution pipeline is estimated to be \$4.85M. Underlying assumptions include availability of natural gas and electricity at the site, and exclude cost of land. For the purpose of the study, capital costs were unitized to net present value using a capital recovery factor based on 20 annuities and 6% cost of money. This analysis makes no assumptions with respect to the appropriate capital structure for the facilities owner, and therefore does not include an appropriate return on equity. Nor does it include profit.

The maintenance cost figures were derived based on a combination of rule of thumb, experience and scaling calculations, and assume domicile type transport operations. The all-in cost of fuel delivered to the specified community of customers, including amortized capital costs, maintenance costs, and costs of fuel (gas and electricity) is estimated to be \$10.32 per GJ. This assumes an average cost for fuel gas delivered to the mother station at \$5.50 per GJ, which is intended to represent the cost of the commodity but excludes the delivery charges for receiving natural gas from the local distribution company, or the capital costs of developing a Custody Transfer Station to receive natural gas directly from the transmission pipeline. No cost is included for gas supply, meter, regulator, etc.

As expected from phase 1, the operating costs for fuel transport dominate the delivery cost at \$2.50 per GJ.

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While keeping in mind that several cost elements have been excluded, the all-in cost (ex. admin. costs and profits) for the multiple user study continues to indicate strong economic viability in comparison to the delivery and consumption of conventional fuels which range in price from \$17-25 for propane and fuel oils to the high \$30's for electricity.

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APPENDIX A – Site Layout Concept Drawings  
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## 1. INTRODUCTION

Jenmar Concepts is retained by QUEST Nova Scotia to provide a study to evaluate the technical and economic parameters of natural gas delivery using compressed natural gas (CNG) technologies. This paper addresses the Phase 2 scope as defined in the QUEST request for proposal (RFP) with focus on a case study wherein an industrial/commercial community of natural gas users is supplied with fuel. Fuel delivery is via road transport from a mother station to a central off-loading facility for fuel introduction to a local community distribution system.

This paper will provide a roll-up of capital and operations costs for the overall delivery system including the local community gas distribution grid. A total “all-in” delivered cost for natural gas is presented.

## 2. SYSTEM OVERVIEW

Similar to the system proposed in phase 1, CNG is delivered to the industrial/commercial community via the following major process steps.

- Compression of gas into mobile storage containers at the mother station
- Delivery of gas by road transport to a centralized de-canting facility
- De-canting and pressure letdown of gas into a gas distribution system.
- Distribution of gas via pipeline distribution system to each connected consumer within the community.

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## 2.1. Mother Station

The mother station design is similar to phase 1 but with the key difference being an upgrade in compression capacity. 2 units of 150 HP compressors are anticipated allowing for 100% redundancy of compression. One unit is capable of meeting the total load within the scheduling required allowing one unit to be off-line in the event of unscheduled downtime or for scheduled maintenance procedures. Due to the high flows to the mobile storage trailers, additional consideration is made in the design of the gas management and interconnecting piping system to allow for the higher flows without incurring unacceptable pressure drops.

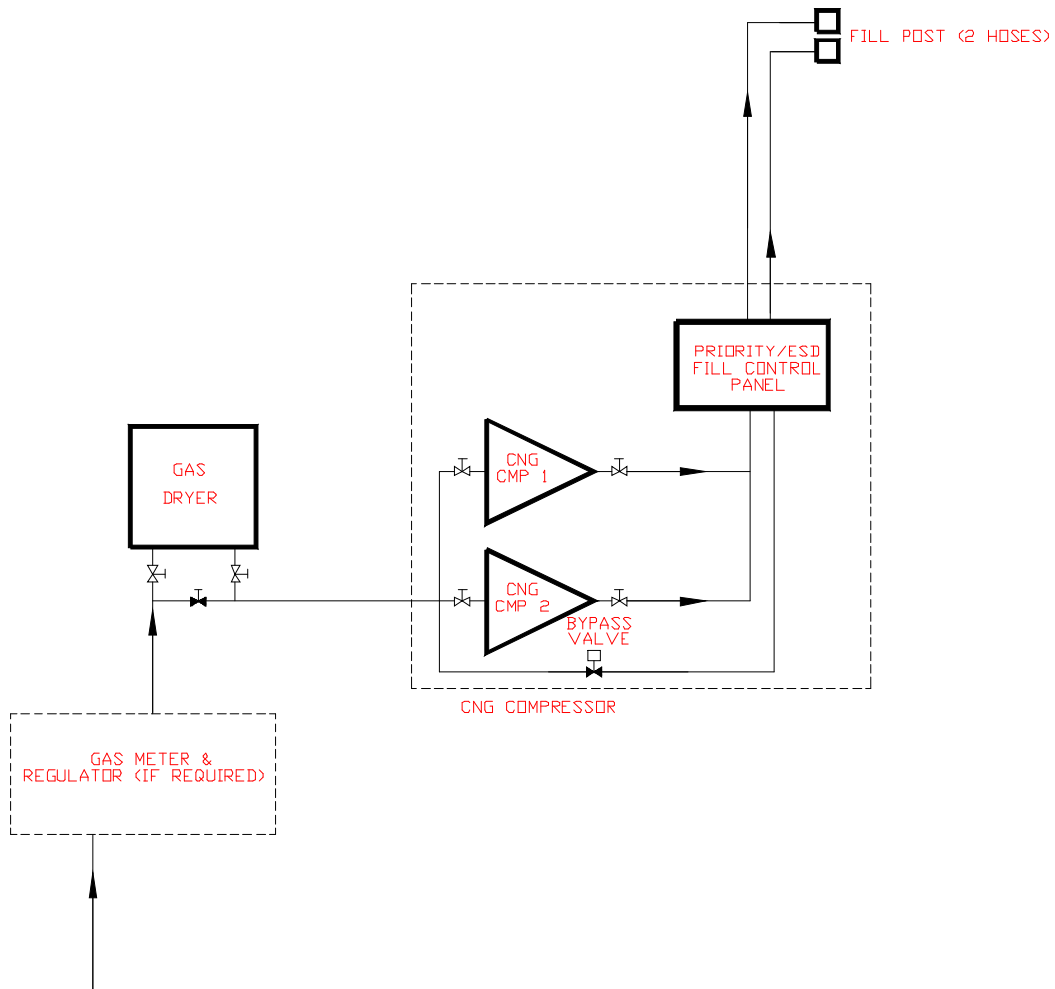


Figure 2.1 – Mother Station System Schematic

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A mother station equipment list is provided in Table 2.1.

**Table 2.1 – Mother Station Major Equipment List**

| Item | Equipment  | Qty |
|------|--|-----|
| 1    | CNG Compressor – Electric Driven<br>Suction pressure: 800 psig (5500 kPa)<br>Discharge pressure: 4000 psig<br>Stages: 2<br>Flow Capacity: 928 scfm @ 800 psig suction<br>Speed: 875 RPM<br>Main drive motor: 150 HP<br>Remote non-hazardous control panel  | 2   |
| 2    | Gas Dryer<br>- PSB Single tower with off-line regeneration<br>- Mounted in weather enclosure   | 1   |
| 3    | Walk-in Weather Enclosure W/ Electrical Controls Room<br>- Class 600 isolation ball valve & flex hose<br>- Electric heating with thermostat<br>- Controls room to include main disconnect, distribution, individual panel disconnects and a transfer switch (for back-up power)<br>- Control panel mounted in controls room and wired to equipment in enclosure. | 1   |
| 4    | 2 Hose Fill Control/Priority/ESD Panel<br>- instrument fittings and tube fittings<br>- For flow to 2500 scfm<br>- 1" line sizes for main flow lines throughout<br>- 1" authorization valves (2 units)<br>- Micromotion meters (2)<br>- Pressure transmitters<br>- Ambient temperature transmitter  | 1   |
| 5    | Fill Post – Double Hose<br>- High flow fill post for flow up to 2500 scfm<br>- ¾" I.D. hoses<br>- ¾" tubing<br>- Heavy duty in-line breakaway – OPW ILB-5<br>- Heavy duty fueling nozzle – OPW CT5000S<br>- ¾" ball valve<br>- Pressure gauge<br>- Vent valve & Hose retractor   | 2   |
| 6    | SCADA System<br>- HMI Display suitable for outdoor location<br>- Fill authorization and data logging based on operator I.D. and password.<br>- Tracking of mobile transport I.D., date/time of fill, product transferred, final fill pressure<br>- Data download to PC (supplied by others)  | 1   |

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## 2.2. Transport Mobile Gas Storage

The case study assumes the use of a 14 tube mobile transport trailer based on use of Transport Canada approved high pressure cylinders. The Fiba Canning supplied 14 Tube Quad Axle Jumbo trailer is selected with the following specifications.

**Table 2.2 – Mobile Storage Transport Specifications**

| Parameter              | Value                   | Unit |
|------------------------|-------------------------|------|
| Model                  | 14 Tube Quad Axle Jumbo |      |
| Supplier               | Fiba Canning            |      |
| No. of cylinders       | 14                      |      |
| Cylinder specification | DOT/TC 3AA-2750         |      |
| Regulations            | TDG CSA B339 compliant  |      |
| Cylinder Type          | Type 1                  |      |
| Service pressure       | 2750                    | Psig |
| Water volume (each)    | 2468                    |      |
| Total capacity         | 8520                    | Sm3  |
|                        | 300,900                 | scf  |
| Trailer Weight (empty) | 41,000                  | kg   |
| Loaded Weight (full)   | 47,152                  | kg   |

## 2.3. De-Canting Station

The de-canting station design is similar to that proposed in Phase 1 but based on a pressure reduction system (PRS) sized for peak flows of 1458 GJ/day or 929 scfm. The de-canting system is a dual train system whereby all regulators can be isolated for maintenance while maintaining flow through a redundant regulator train. The fluid pump and control valve are also provided with full redundancy.

High flow fill posts with high capacity connection nozzles are provided to maintain flow to the PRS even at low mobile storage trailer pressures (< 300 psig).

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### 3. PHASE 2 COMMUNITY CASE STUDY

#### 3.1. Community Definition

For the purposes of the study and as required by the QUEST RFP, a community of natural gas users is profiled in the following table.

**Table 3.1 – Community Load Profile**

| Customer            | Annual        | Avg Daily   | Customer Peak Demand |
|---------------------|---------------|-------------|----------------------|
|                     | GJ/yr         | GJ/day      | GJ/day               |
| 1                   | 65000         | 208         | 350                  |
| 2                   | 65000         | 208         | 350                  |
| 3                   | 65000         | 208         | 350                  |
| 4                   | 65000         | 208         | 350                  |
| 5                   | 20000         | 64          | 85                   |
| 6                   | 30000         | 96          | 125                  |
| 7                   | 30000         | 96          | 125                  |
| 8                   | 10000         | 32          | 50                   |
| <b>Total Annual</b> | <b>350000</b> | <b>1122</b> | <b>1458</b>          |

A capital and operating budget will be generated based on the delivery of fuel to meet the consumption of the community to estimate a base line delivered fuel cost.

#### 3.2. Base Line Operations Assumptions

The following assumptions are made that impact both process and installation design.

- The community of customers must have a continuous and un-interrupted fuel supply delivered to the site.
- The community is located 75 km from the mother station
- The mother station capacity is designed and optimized for the needs of the community.
- The mother station has 100% redundant compression capacity such that with the loss of one compressor due to malfunction or maintenance interval the station remains in service and capable of meeting the full demand.
- Only one compressor operates at any one time to minimize demand charges.
- The station is designed for unattended operation with twice weekly inspections and service as required.

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- The transport operators will be trained to execute filling operations, safety procedures and emergency response.
- Two trailer loading positions will be provided at both the mother station and de-canting stations so that there can be seamless transitions and variability of arrival and departure times.
- The operator will deliver a full trailer and connect it to the de-canting system at the customer site. The newly delivered trailer will be unhitched and the operator will transport the empty trailer back to the mother station for fueling. In this way, the operator will have minimum idle time at the de-canting station.
- At the mother station, the empty trailer will be positioned for filling and connected to the fill post. After connection, operator is not needed for a determined number of hours while the trailer is being filled and may proceed with other work or go off shift as the schedule dictates. Domicile type transport operations are assumed allowing the operator to be employed for other operations independent from gas transport, which may or may not be realized on this particular project. The operations scenario assumed provides for 80 minutes of additional time to allow for traffic interruptions, vehicle breakdowns or other deviations during the process of delivery.
- When the trailer is full at the mother station, it may sit idle for a time before pick-up by the operator. The operator is assumed to have good timing for load pick-up in order to reach the customer site in time before the incumbent trailer is depleted.
- It is assumed that both the mother station and de-canting station controls will have dial-out capability to provide advanced notice to operators for the purpose of transport scheduling.
- Average travel speed for road transport is 60 km/hr.

### 3.3. Mother Station Performance

Table 3.2 provides a summary of the performance of the mother station.

**Table 3.2 – Mother Station Performance Summary**

| <b>MOTHER STATION PERFORMANCE</b>   | <b>Value</b> | <b>Unit</b> |
|-------------------------------------|--------------|-------------|
| station load                        | 350000       | GJ HHV/yr   |
| station volume                      | 881993       | scf         |
| supply gas pressure                 | 800          | psig        |
| no. of compressors available        | 2            |             |
| compressor flow per unit            | 928          | scfm        |
| total compressor flow               | 1856         | scfm        |
| no. of compressors operating        | 1            |             |
| trailer filling rate                | 928          | scfm        |
| fueling time per mobile storage     | 5.1          | hours       |
| compressor operating time per day   | 15.8         | hours       |
| compressor operating hours per year | 5766         | hours       |
| compressor duty cycle               | 69%          |             |
| redundancy                          | 100%         |             |

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Note that filling time for one mobile storage trailer is 5.1 hours at an inflow of 928 scfm.

### 3.4. Mother Station Electrical Load

The mother station site will require an electrical service to be installed. The size of the service is based on the equipment selection and estimated as per Table 3.3.

**Table 3.3 – Electrical Load Calculation – Electric Drive**

| CNG EQUIPMENT ELECTRICAL LOAD LIST - 150 HP ELECTRIC DRIVE |                            |         |                        |       |            |              |                    |              |               |                |                   |
|--|----------------------------|---------|------------------------|-------|------------|--------------|--------------------|--------------|---------------|----------------|-------------------|
| Item   | Load Description           | Voltage | Circuit Amp Max Rating | Amps  | Efficiency | Power Factor | Mtr Shaft Pwr (hp) | Power (kW)   | Power(kVA)    | Peak Operation | Station Idle Load |
| 1  | IMW50/150 Compressor No. 1 |         |                        |       |            |              |                    |              |               |                |                   |
| 2  | Main Drive Motor           | 575     |                        | 147.5 | 92%        | 0.9          | 150                | 121.63       | 135.14        | YES            | NO                |
| 3  | Cooling Fan Motor No. 1A   | 575     |                        | 5.4   | 88%        | 0.9          | 5                  | 4.24         | 4.71          | YES            | NO                |
| 4  | Cooling Fan Motor No. 1B   | 575     |                        | 5.4   | 88%        | 0.9          | 5                  | 4.24         | 4.71          | YES            | NO                |
| 5  | Compressor Block Heater    | 120     |                        | 2.5   | 100%       | 1.0          |                    | 0.30         | 0.30          | YES            | YES               |
| 6  | Compressor Controls        | 120     |                        | 16.7  | 100%       | 1.0          |                    | 2.00         | 2.00          | YES            | YES               |
| 7  |                            |         |                        |       |            |              |                    |              |               |                |                   |
| 1  | IMW50/150 Compressor No. 2 |         |                        |       |            |              |                    |              |               |                |                   |
| 2  | Main Drive Motor           | 575     |                        | 147.5 | 92%        | 0.9          | 150                | 121.63       | 135.14        | YES            | NO                |
| 3  | Cooling Fan Motor No. 2A   | 575     |                        | 5.4   | 88%        | 0.9          | 5                  | 4.24         | 4.71          | YES            | NO                |
| 4  | Cooling Fan Motor No. 2B   | 575     |                        | 5.4   | 88%        | 0.9          | 5                  | 4.24         | 4.71          | YES            | NO                |
| 5  | Compressor Block Heater    | 120     |                        | 2.5   | 100%       | 1.0          |                    | 0.30         | 0.30          | YES            | YES               |
| 6  | Compressor Controls        | 120     |                        | 16.7  | 100%       | 1.0          |                    | 2.00         | 2.00          | YES            | YES               |
| 7  |                            |         |                        |       |            |              |                    |              |               |                |                   |
| 8  | Gas Dryer                  |         |                        |       |            |              |                    |              |               |                |                   |
| 9  | Gas Dryer - blower motor   | 575     |                        | 23.4  | 88%        | 0.9          | 2.0                | 1.70         | 1.88          | NO             | NO                |
| 10   | Gas Dryer - fan motor      | 575     |                        | 23.4  | 88%        | 0.9          | 0.25               | 0.21         | 0.24          | NO             | NO                |
| 11   | Gas Dryer - Heater         | 575     |                        | 15.1  | 100%       | 1.0          |                    | 15.00        | 15.00         | NO             | NO                |
| 12   |                            |         |                        |       |            |              |                    |              |               |                |                   |
| 13   | Other 575V Loads           |         |                        |       |            |              |                    |              |               |                |                   |
| 14   | Enclosure Heater           | 575     |                        | 5.0   | 100%       | 1.0          |                    | 5.00         | 5.00          | YES            | YES               |
| 15   |                            |         |                        |       |            |              |                    |              |               |                |                   |
| 16   | Yard Lighting              |         |                        |       |            |              |                    |              |               |                |                   |
| 17   | Yard Light No. 1           | 377     |                        | 0.8   | 100%       | 1.0          |                    | 0.50         | 0.50          | YES            | YES               |
| 18   | Yard Light No. 2           | 377     |                        | 0.8   | 100%       | 1.0          |                    | 0.50         | 0.50          | YES            | YES               |
| 19   |                            |         |                        |       |            |              |                    |              |               |                |                   |
| 20   | Other 120V Loads           |         |                        |       |            |              |                    |              |               |                |                   |
| 28   | electrical room heater     | 120     |                        | 4.8   | 100%       | 1.0          |                    | 1.00         | 1.00          | YES            | YES               |
| 21   | Enclosure Lighting         | 120     | 15                     | 5     | 100%       | 1.0          |                    | 0.60         | 0.60          | YES            | YES               |
| 22   | 120V Outlet Plug/Light #1  | 120     | 15                     | 0     | 100%       | 1.0          |                    | 0.00         | 0.00          | NO             | NO                |
| 23   | 120V Outlet Plug/Light #2  | 120     | 15                     | 0     | 100%       | 1.0          |                    | 0.00         | 0.00          | NO             | NO                |
| 24   | SCADA System               | 120     | 15                     | 5     | 100%       | 1.0          |                    | 0.60         | 0.60          | YES            | YES               |
| 25   | Spare 1                    | 120     | 15                     | 0     | 100%       | 1.0          |                    | 0.00         | 0.00          | NO             | NO                |
| 26   | Spare 2                    | 120     | 15                     | 0     | 100%       | 1.0          |                    | 0.00         | 0.00          | NO             | NO                |
| <b>Total</b>   |                            |         |                        |       |            |              |                    | 289.92       | <b>319.05</b> | kVA            |                   |
| Service Voltage  |                            |         |                        |       |            |              |                    | <b>575</b>   | V             |                |                   |
| Service Amperage   |                            |         |                        |       |            |              |                    | <b>320.4</b> | A             |                |                   |
| Peak Operating Load  |                            |         |                        |       |            |              |                    | <b>301.9</b> | kVA           |                |                   |
| Station Idle Load  |                            |         |                        |       |            |              |                    | <b>12.8</b>  | kVA           |                |                   |

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A peak load of 301.9 KVA is projected with two compressor units operating. This load includes non-CNG related loads including yard lighting, and provision for some additional small loads. It is expected that a 400 kVA/600V service is required.

### 3.5. Operations Summary

To estimate transport operating costs, a time study was conducted to map the operations process. The results of the time study are shown in the following table.

**Table 3.4 – Operations Time Study**

| <b>OPERATIONS TIME STUDY</b>                              | Parameter | Unit  |
|---|-----------|-------|
| <b>Trailer Use Time</b>                                   |           |       |
| connect nozzle/unhitch empty trailer for filling (mother) | 15        | min   |
| filling duration  | 304       | min   |
| hitch/disconnect nozzle from full trailer (mother)        | 15        | min   |
| travel time to client site                                | 75        | min   |
| connect nozzle/unhitch full trailer (de-canting)          | 15        | min   |
| de-canting time   | 461       | min   |
| hitch/disconnect nozzle from empty trailer (de-canting)   | 15        | min   |
| travel to mother station                                  | 75        | min   |
| extra margin time   | 120       | min   |
| total de-canting time                                     | 7.7       | hours |
| total transport time                                      | 10.6      | hours |
| total minimum cycle time                                  | 18.2      | hours |
| actual cycle time   | 23.8      | hours |
| trailer idle time   | 5.6       | hours |
| minimum no. of trailers required                          | <b>3</b>  |       |
| <b>Labor Time</b>   |           |       |
| connect nozzle/unhitch empty trailer for filling (mother) | 15        | min   |
| hitch/disconnect nozzle from full trailer (mother)        | 15        | min   |
| travel time to client site                                | 75        | min   |
| connect nozzle/unhitch full trailer (de-canting)          | 15        | min   |
| hitch/disconnect nozzle from empty trailer (de-canting)   | 15        | min   |
| travel to mother station                                  | 75        | min   |
| extra margin time   | 120       | min   |
| total labor input per delivery                            | 5.5       | hours |

The operations study highlights the following important points.

- 3 mobile storage trailers are required to service the distribution facility.

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- The cycle time for each trailer (filling to de-canting and back to filling) is 23.8 hours. Of this time, the trailer is sitting idle for 5.6 hours (i.e. no activity).
- A fuel delivery must be made every 7.7 hours.
- The total labor input per trailer load cycle is only 5.5 hours. This includes 2 hours of contingency time in the event of an accident, traffic jam or other travel issues. In addition, 5.6 hours of trailer idle time remain to allow for variability in consumption.
- A labor shift starts every 7.7 hours and extends for 5.5 hours to make a delivery and return an empty trailer to the mother station for filling.
- If customer demand were to increase to 509,000 GJ a 4<sup>th</sup> trailer would need to be added to the fleet.
- If the customer load were to increase above 530,000 GJ while maintaining 100% mother station compression redundancy additional compression capacity would be required.

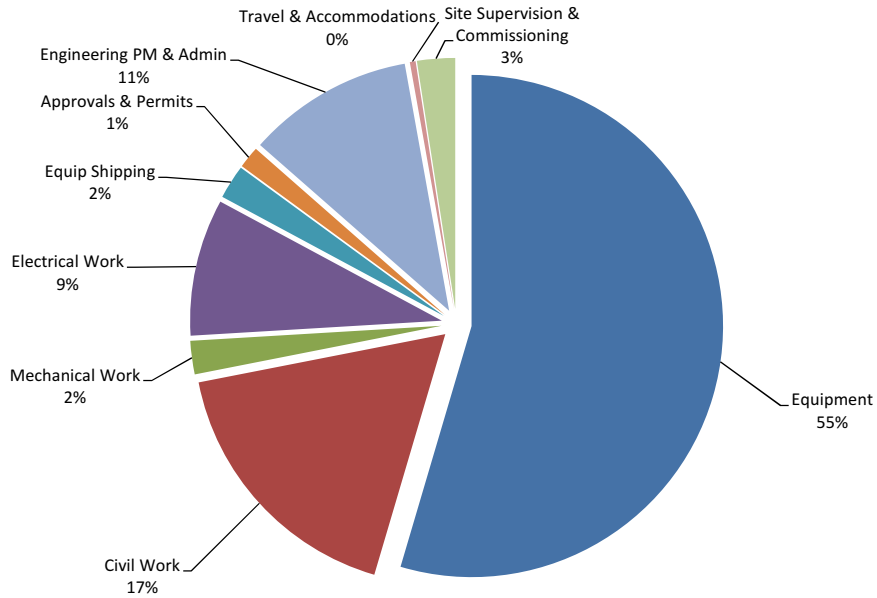
### 3.6. Project Capital Cost Breakdown

A detailed breakdown of the capital costs for both the mother and de-canting stations is estimated in Appendix B. The capital costs are based on the site layouts of Appendix A and the listed assumptions. For the mother station, costs are particularly sensitive to the location of the utilities, namely the gas supply and electrical service. It is for this reason that the compressors are located close to the road where gas and electricity are assumed to be available. All capital cost estimates are based on year 2012.

Jenmar Concepts' opinion of total probable capital cost for an electric driven compressor mother station is estimated at **\$1,767,000**. This total includes a 10% contingency. Cost breakdown by major category is shown in the following figures.

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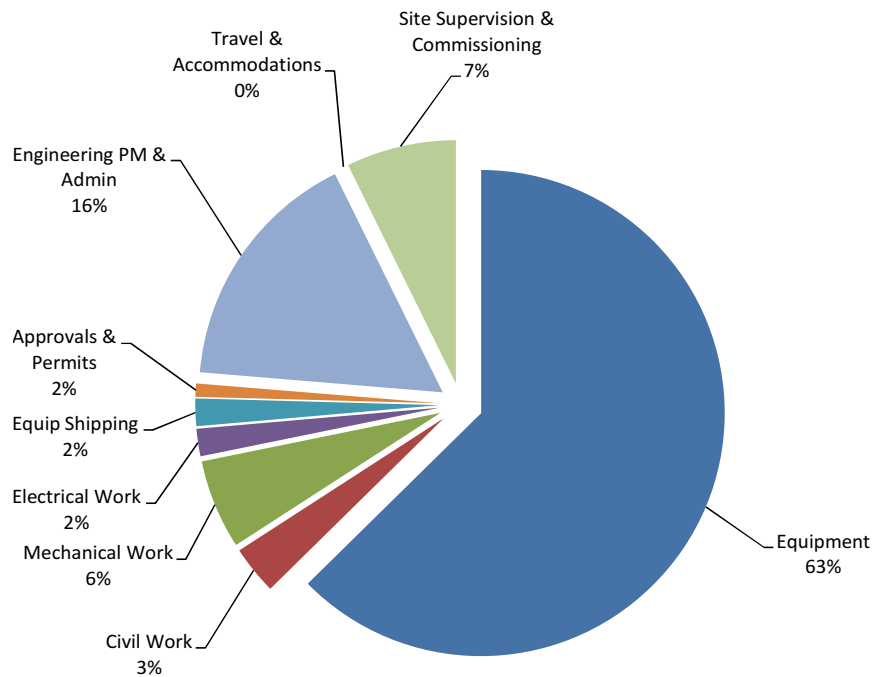


**Figure 3.1 – Mother Station Cost Breakdown - Electric Drive**

Jenmar Concepts' opinion of total probable capital cost for the de-canting station is estimated to be **\$301,800.00** with breakdown as shown.

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**Figure 3.2 – De-Canting Station Cost Breakdown**

Based on supplier's quotes, the cost for three units of mobile storage transport trailers is \$400,000 per unit or **\$1,200,000** for the fleet of three trailers required.

The cost for the community gas distribution system is provided by Heritage Gas and estimated at **\$1,575,000**. This is based on simplifying assumptions that are deemed to be representative for the purpose of this study.

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Probable capital costs for the project are summarized as follows:

**Table 3.5 – Total Capital Cost**

|                                    |                        |
|------------------------------------|------------------------|
| Mother Station                     | \$ 1,767,371.00        |
| Mobile Storage Transport Equipment | \$ 1,200,000.00        |
| De-Canting Station                 | \$ 303,468.00          |
| Distribution Pipeline              | \$ 1,575,000.00        |
| <b>Total Capital</b>               | <b>\$ 4,845,839.00</b> |

### 3.7. Operations Cost Breakdown

The operations costs for the mother station and de-canting stations are comprised of

- natural gas consumption
- electrical energy consumption
- maintenance and service

#### 3.7.1. Fuel Gas Costs

A small amount of the natural gas delivered is consumed for heating at the de-canting station. For the purposes of this study a fuel gas cost of \$5.50 per GJ is assumed (average cost provided by Heritage Gas). This is intended to represent the cost of the commodity but excludes the delivery charges for receiving natural gas from the local distribution company, or the capital costs of developing a Custody Transfer Station to receive natural gas directly from the transmission pipeline. This study assumes the selection of electrically driven compressors rather than gas driven, so no gas is consumed by the compression process.

#### 3.7.2. Electric Power and Fuel Gas Costs

For the mother and de-canting stations, the operating costs consist of electric power and fuel gas consumption. For electric power, the Small Industrial rate from Nova Scotia Power was applied. Operating costs are shown in the table below.

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**Table 3.6 – Energy Cost Summary**

| <b>Mother Station</b>     | electric        | unit   |
|---------------------------|-----------------|--------|
| electricity               | \$ 0.328        | per GJ |
| fuel gas                  | \$ -            | per GJ |
| <b>Total</b>              | <b>\$ 0.328</b> | per GJ |
| <b>De-Canting Station</b> |                 |        |
| electricity               | \$ 0.008        | per GJ |
| fuel gas                  | \$ 0.048        | per GJ |
| <b>Total</b>              | <b>\$ 0.055</b> | per GJ |

3.7.3. Maintenance And Service Costs

Mother station maintenance and service costs include costs for operating labor, maintenance and security. Nova Scotia Power Engineering regulations categorize the mother station to be a compressor plant requiring supervision by a trained and licensed operator. The size of the plant allows the supervision to be periodic (check plant every 12 hours) along specific guarding requirements. The costs for continuous remote security monitoring, 3 hours per day of operating supervision, regular maintenance and service, spare parts and consumables are all included in the maintenance and service cost estimate (refer to Appendix C for detailed spreadsheet). The maintenance cost figures were derived based on a combination of rule of thumb, experience and scaling calculations. The following figures are believed to be conservative (high).

**Table 3.7 – Mother Station Maintenance and Service Costs**

| <b>MOTHER STATION</b>                 | Parameter            | Unit       |
|---------------------------------------|----------------------|------------|
| <b>Maintenance Cost</b>               |                      |            |
| compressor type                       | electric             |            |
| station security remote monitoring    | \$ 18,000.00         |            |
| fixed yearly cost for operator        | \$ 55,000.00         |            |
| fixed yearly cost for maintenance     | \$ 25,000.00         |            |
| incremental maintenance cost per unit | \$ 0.016             | per gle    |
| incremental maintenance cost per unit | \$ 0.416             | per GJ HHV |
| monthly maintenance cost              | \$ 14,204.55         |            |
| yearly maintenance cost               | \$ <b>243,454.55</b> |            |
| maintenance cost per unit compressed  | \$ 0.696             | per GJ HHV |
| maintenance cost per unit compressed  | \$ 0.024             | per gle    |

Maintenance cost for the de-canting station is very low and is estimated at \$0.030 per GJ. This is based on a weekly service call and some spare parts (refer to Appendix C for more detail).

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Maintenance on mobile storage trailers consists of running costs and fixed costs related to cylinder re-certification. Industry “Rule of thumb” suggests that trailer maintenance costs are approximately \$0.025 per km per axle. Using this guideline we can predict annual cost for as follows.

- Distance per trip – 2 x 75 kms = 150 kms
- Trips per year – 1138 (23.8 hour cycle time, 365 days per year)
- Total kilometers – 170,700 kms

Yearly cost per 3 trailer fleet (@ \$0.10/km for 4 axle trailer) = \$17,070.

Additional costs are incurred for maintaining the cylinders which is mainly comprised of re-qualification expenses. Type 1 steel cylinders (as recommended by this report) require requalification every ten years. Fiba Canning estimates re-qualification costs at \$10,000 per trailer. As a comparison, Dynetek BT-30 trailers (Type 3 cylinders) have a similar requalification cost but currently require requalification every 3 years (an application has been made with Transport Canada to allow requalification every 5 years).

Total maintenance cost on the trailers including requalification servicing is estimated to be \$0.057 per GJ.

A summary of maintenance costs is shown below.

**Table 3.8 – Maintenance Cost Summary**

|                    | electric        | unit   |
|--------------------|-----------------|--------|
| mother station     | \$ 0.696        | per GJ |
| mobile storage     | \$ 0.057        | per GJ |
| de-canting station | \$ 0.030        | per GJ |
| Total              | <b>\$ 0.783</b> | per GJ |

#### 3.7.4. Mobile Storage Transport Operations

The study assumes that fuel deliveries will be contracted to a bulk gas and liquids transport company. The fuel provider will own the mobile storage trailers but the transport company will supply and operate its own fleet of tractors. Typical haulage rates are used for domicile carriers as shown below.

- Cost Per Km Travelled - \$3.40 per km
- Non-Rolling Rate – \$80.55 per hour (For time spent at the mother or de-canting station making connections/disconnections and possibly some waiting time.)

On this basis operating costs are estimated for each delivery at \$751 per delivery or \$2.50 per GJ.

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### 3.8. Capital Cost Recovery

To account for the cost of capital a cost recovery model is used to calculate a present value of capital funds paid over a defined number of annuities and interest rate. The number of annuities used and the interest rate are 20 years and 6% respectively. This analysis makes no assumptions with respect to the appropriate capital structure for the facilities owner, and therefore does not include an appropriate return on equity. Nor does it include profit. On this basis a yearly cost of capital is estimated and amortized by the number of gigajoules of fueled delivered. The results are shown below.

**Table 3.9 – Capital Cost Recovery Summary**

| Parameter                                    | Electric Driven | Unit         |
|--|-----------------|--------------|
| cost of money                                | 6.0%            |              |
| number of annuities (years to recover)       | 20              |              |
| capital cost recovery factor                 | 0.087           |              |
| <b>MOBILE STORAGE EQUIPMENT</b>              |                 |              |
| capital cost per mobile storage              | \$ 400,000.00   |              |
| number of trailers required                  | 3               |              |
| capital cost for all trailers                | \$ 1,200,000.00 |              |
| annual cost                                  | \$ 104,621.47   |              |
| cost per fuel unit                           | \$ 0.30         | per GJ HHV   |
| <b>MOTHER STATIONS</b>                       |                 |              |
| capital cost for station                     | \$ 1,767,371.00 |              |
| annual cost                                  | \$ 154,087.46   |              |
| cost per fuel unit                           | \$ 0.44         | per GJ HHV   |
| <b>DE-CANTING STATION</b>                    |                 |              |
| capital cost for station                     | \$ 303,468.00   |              |
| annual cost                                  | \$ 26,457.72    |              |
| cost per fuel unit                           | \$ 0.08         | per GJ HHV   |
| <b>GAS DISTRIBUTION PIPELINE</b>             |                 |              |
| capital cost for distribution system         | \$ 1,575,000.00 |              |
| annual cost                                  | \$ 137,315.68   |              |
| cost per fuel unit                           | \$ 0.39         | \$/GJ        |
| <b>Total capital cost per unit delivered</b> | <b>\$ 1.21</b>  | <b>\$/GJ</b> |

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### 3.9. Delivered Fuel Cost

The following table presents the all-in cost of fuel delivered to the community of customers. Note that the fuel costs derived from the study do **not** include administration costs and profit.

**Table 3.10 – Total Fuel Delivery Cost**

|                                 | <b>Electric Drive</b> | <b>Units</b> |
|---------------------------------|-----------------------|--------------|
| <b>Cost Of Fuel Gas</b>         | <b>\$ 5.500</b>       | per GJ       |
| <b>Sub-Total Operating Cost</b> | <b>\$ 3.611</b>       | per GJ       |
| mother station                  | \$ 1.024              | per GJ       |
| CNG transport                   | \$ 2.500              | per GJ       |
| de-canting                      | \$ 0.087              | per GJ       |
| <b>Sub-Total Capital Cost</b>   | <b>\$ 1.207</b>       | per GJ       |
| mother station                  | \$ 0.440              | per GJ       |
| CNG transport                   | \$ 0.299              | per GJ       |
| de-canting                      | \$ 0.076              | per GJ       |
| gas distribution pipeline       | \$ 0.392              | per GJ       |
| <b>Total Delivered Cost</b>     | <b>\$ 10.32</b>       | per GJ       |

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#### **4. SUMMARY AND CONCLUSIONS**

The community case study provides a base line for delivered fuel cost to a central de-canting facility at which compressed natural gas is off-loaded for insertion into a local distribution pipeline. For the purpose of the study an average annual load of 350,000 GJ was indicated for use by a community located 75 kilometers from the mother station.

The all-in delivered fuel cost was estimated to be \$10.32 per GJ using an electric driven compression system at the mother station.

It is noteworthy that economies have not been realized with the increase in load volumes over the single user study. This increase is mainly due to (1) increased capital investment in both the mother and de-canting station, (2) the additional cost for a third trailer, (3) increased operations cost due to the increased distance for travel and (4) the additional investment in a local pipeline distribution system. The local pipeline distribution system, albeit at high capital cost, is essential to the economics of delivery. The largest load of any single customer was estimated at 65,000 GJ. At this load level, individual trailer deliveries are expected to be much less economic due to the low capital utilization in the trailers. This result was predicted in the sensitivity analysis of the Phase 1 study. Additional customers connecting to the community distribution system are expected to further increase the economic viability of the delivery system by increased capital utilization and reducing per unit operations costs.

It was noted in the Phase 1 report that the single largest contributor to delivered cost is transportation operations costs. This continued to hold true as transportation costs based on time and distance increased on a per GJ basis due to the 50% increase in delivery distance.

The all-in cost (ex. admin. costs and profits) for the multiple user study continues to indicate strong economic viability in comparison to the delivery and consumption of conventional fuels which range in price from \$17-25 for propane and fuel oils to the high \$30's for electricity.

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## **APPENDIX A**

### **Site Layout Concept Drawings**

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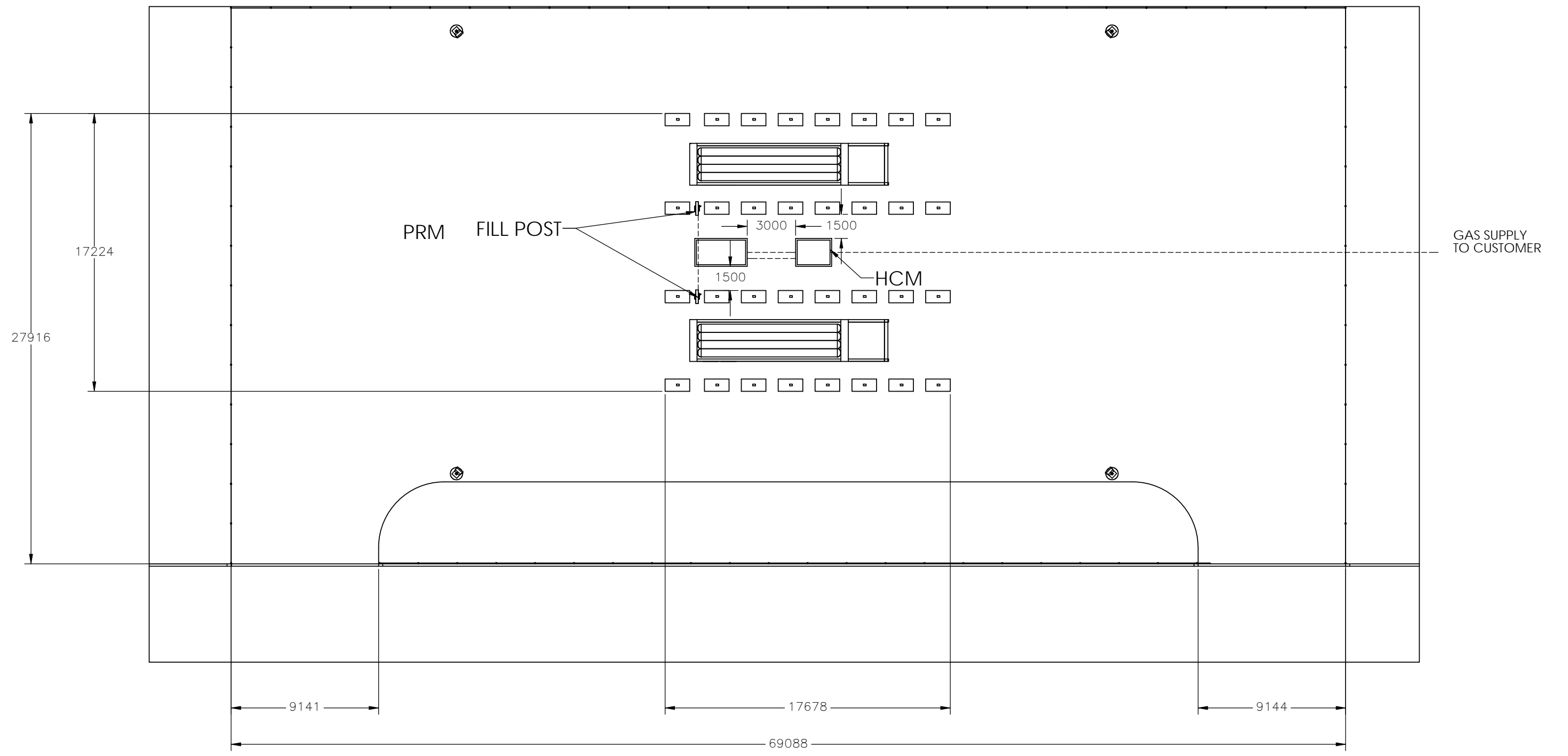


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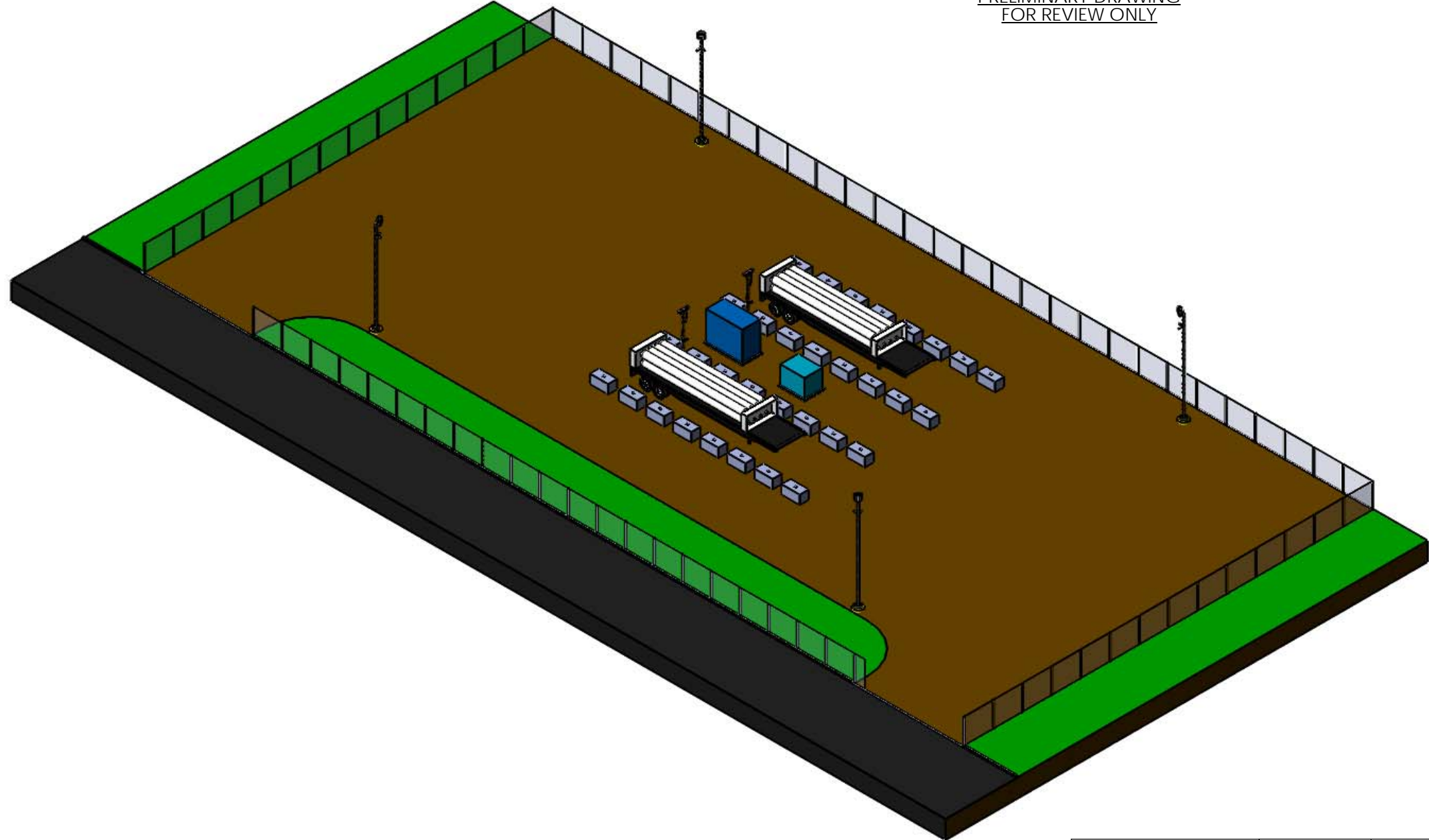




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| UNLESS OTHERWISE SPECIFIED,<br>ALL DIMENSIONS ARE IN INCHES |                    |      |       | TITLE<br><b>DECANTING STATION<br/>SITE LAYOUT</b> |      |  |                     |
| UNITS   | INCHES             | X/X  | ±1/16 | REF.  | SIZE | PROJECT: QUEST NOVA SCOTIA                     | REV                 |
| FINISH  | 64 MICRO IN.       | .X   | ±.1   | DR.   KDT 2012/01/11                              | D    | DWG.#: QN-0003-00                              | 0                   |
| INNER RADII   | .020 MAX.          | .XX  | ±.02  | CK.   MAE 2012/02/09                              |      | SCALE: 1:125                                   | WEIGHT 307056170700 |
| OUTER EDGE  | .007±.002<br>X 45° | .XXX | ±.005 | AP.   MAE 2012/02/09                              |      |  |                     |

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| UNITS   | INCHES             | X/X   | ±1/16 | REF.   | SIZE                       |
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| INNER RADII   | .020 MAX.          | .XX   | ±.02  | CK.   MAE 2012/02/09                           | DWG.#: QN-0003-00          |
| OUTER<br>EDGE   | .007±.002<br>X 45° | .XXX  | ±.005 | AP.   MAE 2012/02/09                           | SCALE: 1:150               |
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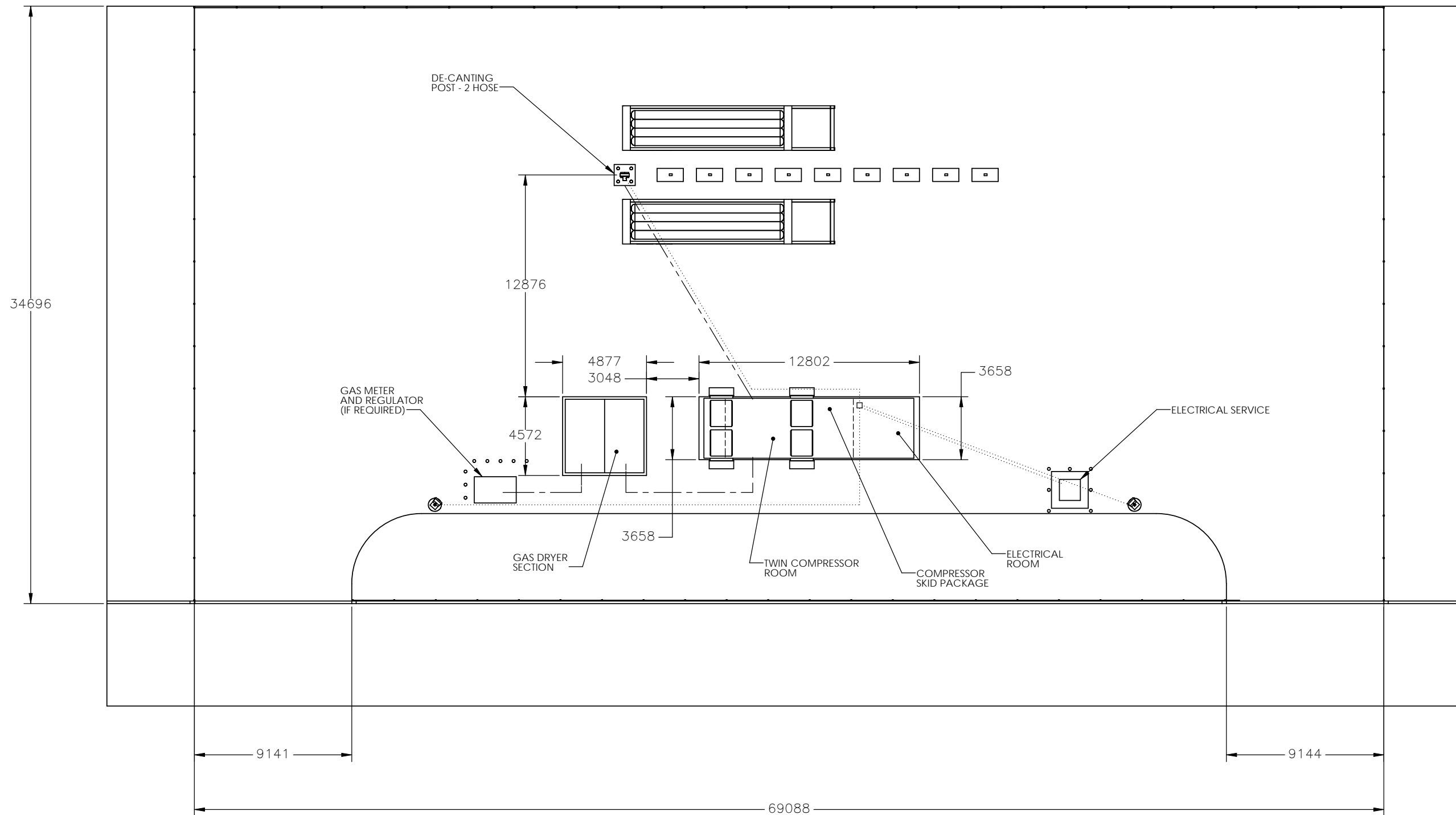
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|        | HIGH PRESSURE GAS LINES U/G |
|        | LOW PRESSURE GAS LINES      |
|        | ELECTRICAL CONDUITS         |

|  |              |                            |             |  |  |
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|  |              |                            |             | JENMAR COMPRESSORS INC.<br>LANGLEY, BC, CANADA |  |
| TITLE<br><b>MOTHER STATION<br/>SITE LAYOUT</b> |              |                            |             |  |  |
| REF. I   | SIZE         | PROJECT: QUEST NOVA SCOTIA | REV         | XX   |  |
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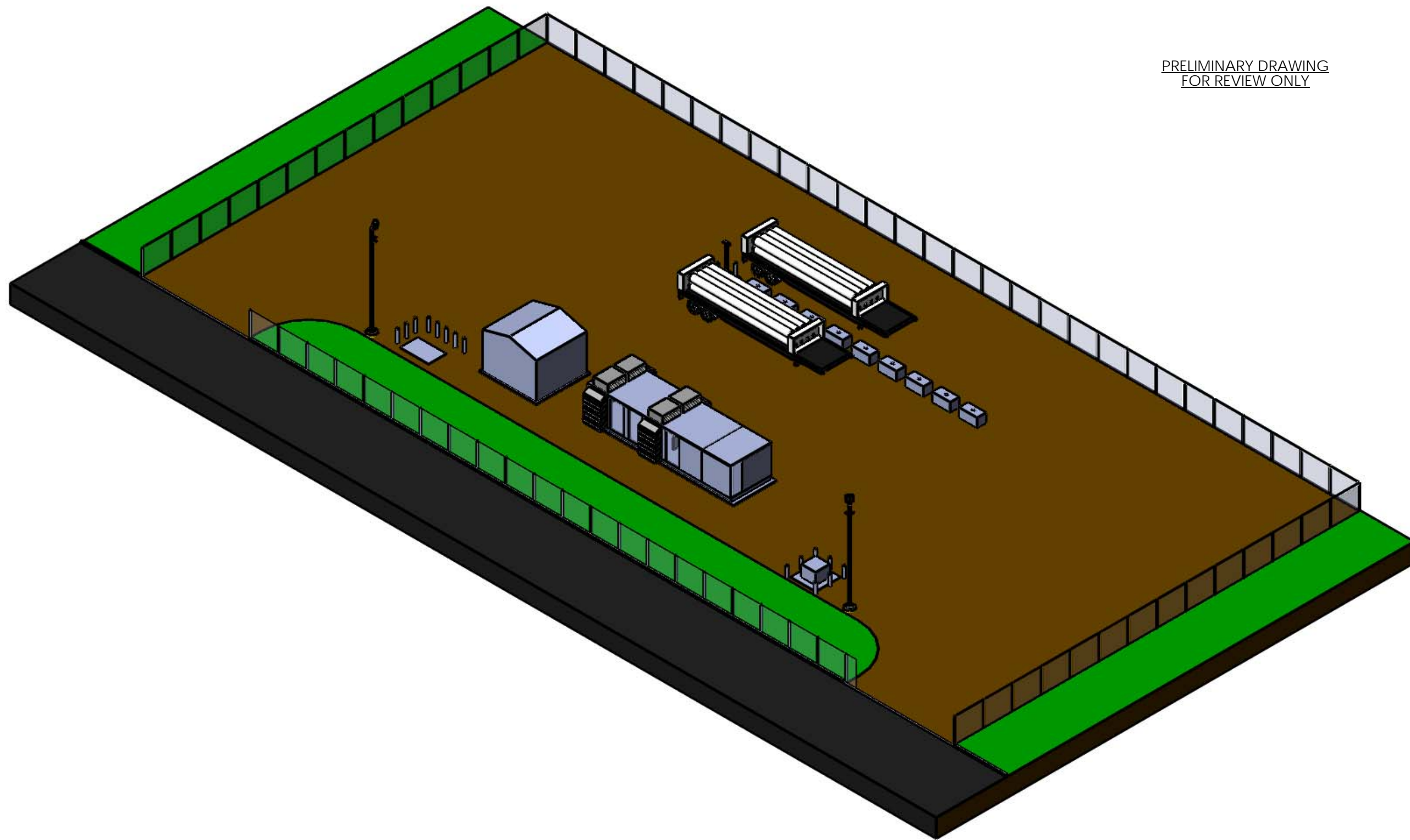
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

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|---|--------------|---|-------------|--|--|
|  |              |  |             | JENMAR COMPRESSORS INC.<br>LANGLEY, BC, CANADA |  |
| TITLE: MOTHER STATION SITE LAYOUT   |              |   |             |  |  |
| REF.  | SIZE         | PROJECT: QUEST NOVA SCOTIA  |             | REV  |  |
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# **APPENDIX B**

## **Capital Cost Spreadsheets**

**JENMAR CONCEPTS**  
Consulting Engineers  
**TURN-KEY MOTHER CNG STATION BUDGET**  
**ELECTRIC DRIVE**



Owner: TBD  
Project: Phase 2 - CNG Bulk Fueling Facility  
Prepared by: Mark Epp  
Date: March 2, 2012  
Doc. No.: QN-0006-01  
Revision: 00

**Assumptions and comments**

1. Costs based on owner issuing purchase orders direct to suppliers/contractors
2. Costs do not include risk or profit
3. Based on typical site plan
4. Does not include cost of land. Assumes land is developed and has access
5. Gas supply based on fuel gas supply at 800 psig
6. No cost included for gas supply, meter, regulator
6. Electrical service costs are rough estimates. No costs available from NS Power

| Item | Description  | Qty | UOM | Cost             | Subtotal             | Contractor                    | Notes                               |
|------|--|-----|-----|------------------|----------------------|-------------------------------|-------------------------------------|
| 1    | <b>Equipment</b>   |     |     |                  |                      |                               |                                     |
| 2    | IMW50-275DA-150-4000-2A CNG Compressors - Electric Drive   | 2   | ea. | \$ 163,000.00    | \$ 326,000.00        | IMW (Chilliwack, BC)          | IMW quotation                       |
| 3    | PSB Model NG-SR-30-3-770-DDP - single tower regen  | 1   | ea. | \$ 235,000.00    | \$ 235,000.00        | IMW (Chilliwack, BC)          | PSB budget quotation                |
| 4    | compressor enclosure c/w electrical room.cold weather package  | 1   | ea. | \$ 94,000.00     | \$ 94,000.00         | IMW (Chilliwack, BC)          | IMW quotation                       |
| 5    | gas dryer enclosure  | 1   | ea. | \$ 40,000.00     | \$ 40,000.00         |                               | allowance                           |
| 6    | Buffer storage - single ASME, MAWP=5500 psig, 35 cu. Ft water volume   | 1   | ea. | \$ 40,000.00     | \$ 40,000.00         | IMW (Chilliwack, BC)          | IMW quotation                       |
| 7    | Metered Time Fill and ESD Panel  | 1   | ea. | \$ 46,000.00     | \$ 46,000.00         | IMW (Chilliwack, BC)          | IMW quotation                       |
| 8    | Fill Post - Single Hose High Capacity  | 2   | ea. | \$ 24,000.00     | \$ 48,000.00         |                               | IMW quotation                       |
| 9    | SCADA System   | 1   | ea. | \$ 24,000.00     | \$ 24,000.00         |                               | IMW quotation                       |
| 10   | light poles  | 2   | ea. | \$ 4,500.00      | \$ 9,000.00          |                               | estimate                            |
| 11   | Gas meter and regulator set  | 1   | ea. | \$ -             | \$ -                 |                               | absorbed by gas utility             |
| 12   | skid packaged odorizing system   | 1   | ea. | \$ 7,560.00      | \$ 7,560.00          | Priority Projects (Nisku, AB) | Priority Projects quotation         |
| 13   | truck grounding and interlock system   | 1   | ea. | \$ 2,500.00      | \$ 2,500.00          |                               | estimate                            |
| 14   | CCTV security camera system and interconnection  | 1   | ea. | \$ 8,000.00      | \$ 8,000.00          |                               | estimate                            |
| 15   |  |     |     | <b>Subtotal:</b> | <b>\$ 880,060.00</b> |                               |                                     |
| 16   | <b>Civil Work</b>  |     |     |                  |                      |                               |                                     |
| 17   | oncrete Slab - Compressor Skid - 30'-6" X 7'-6" X 8" thick   | 1   | ea. | \$ 33,500.00     | \$ 33,500.00         |                               | estimate from recent job            |
| 18   | concrete Slab - Gas Dryer - 18' X 14' X 8" thick   | 1   | ea. | \$ 26,250.00     | \$ 26,250.00         |                               |                                     |
| 19   | concrete slab - gas meter and odorizer - 7' x 10' x 8" thick   | 1   | ea. | \$ 7,300.00      | \$ 7,300.00          |                               |                                     |
| 20   | gas storage footings   | 1   | lot | \$ 3,000.00      | \$ 3,000.00          |                               |                                     |
| 21   | mechanical installation of two light poles   | 2   | ea. | \$ 500.00        | \$ 1,000.00          |                               | estimate from recent job            |
| 22   | grading and site gravel  | 1   | ea. | \$ 80,000.00     | \$ 80,000.00         |                               | estimate from recent job            |
| 23   | concrete blocks  | 33  | ea. | \$ 110.00        | \$ 3,630.00          |                               | quote                               |
| 24   | concrete block delivery and installation   | 33  | ea. | \$ 75.00         | \$ 2,475.00          |                               | estimate from recent job            |
| 25   | pipe bollards - 6" - gas meter/regulator   | 8   | ea. | \$ 670.00        | \$ 5,360.00          |                               | material and installation           |
| 26   | pipe bollards - 6" - electrical service  | 8   | ea. | \$ 670.00        | \$ 5,360.00          |                               | material and installation           |
| 27   | compressor slab - 42' x 12' x 12" thick  | 1   | ea. | \$ 52,500.00     | \$ 52,500.00         |                               | estimate                            |
| 28   | light post foundations   | 4   | ea. | \$ 2,500.00      | \$ 10,000.00         |                               | material and pile driving           |
| 29   | chain link fence and entrance gates  | 665 | ft  | \$ 54.00         | \$ 35,910.00         |                               |                                     |
| 30   | trenching to light poles   | 80  | ft  | \$ 140.00        | \$ 11,200.00         |                               | estimate from recent job            |
| 31   |  |     |     | <b>Subtotal:</b> | <b>\$ 277,485.00</b> |                               |                                     |
| 32   | <b>Mechanical Work</b>   |     |     |                  |                      |                               |                                     |
| 33   | <u>HP gas line materials - fillpost (6 lines)</u>  |     |     |                  |                      |                               |                                     |
| 34   | 1/2" x .065 316SS tube - ASTM A213 TP316SS   | 300 | ft  | \$ 12.00         | \$ 3,600.00          |                               | recent quotes                       |
| 35   | PVC sheath - 1"  | 300 | ft  | \$ 1.50          | \$ 450.00            |                               | estimate - Jenmar recent experience |
| 36   | elbows - 2"  | 16  | ea. | \$ 4.00          | \$ 64.00             |                               | estimate - Jenmar recent experience |
| 37   | reducers - 1" x 2"   | 32  | ea. | \$ 2.00          | \$ 64.00             |                               | estimate - Jenmar recent experience |
| 38   | tees - 1"  | 8   | ea. | \$ 2.00          | \$ 16.00             |                               | estimate - Jenmar recent experience |
| 39   | elbows - 1"  | 8   | ea. | \$ 2.00          | \$ 16.00             |                               | estimate - Jenmar recent experience |
| 40   | bushings - 1" x 1/2 NPT  | 16  | ea. | \$ 2.00          | \$ 32.00             |                               | estimate - Jenmar recent experience |
| 41   | liquid-tite fittings - 1/2" x 1/2 NPT  | 16  | ea. | \$ 4.00          | \$ 64.00             |                               | estimate - Jenmar recent experience |
| 42   | isolation valves   | 2   | ea. | \$ 450.00        | \$ 900.00            |                               | estimate - Jenmar recent experience |
| 43   | <u>HP gas line installation</u>  |     |     |                  |                      |                               |                                     |
| 44   | specialty installation labor   | 5   | day | \$ 1,500.00      | \$ 7,500.00          |                               | estimate - Jenmar recent experience |
| 45   | hydrostatic testing  | 2   | day | \$ 1,500.00      | \$ 3,000.00          |                               | estimate - Jenmar recent experience |
| 46   | <u>Low Pressure Gas Piping - gas meter/dryer/compressor</u>  |     |     |                  |                      |                               |                                     |
| 47   | 2" sch. 80 pipe and Class 600 fittings/valves  | 1   | lot | \$ 4,500.00      | \$ 4,500.00          |                               |                                     |
| 48   | pressure welding labor   | 60  | hr  | \$ 125.00        | \$ 7,500.00          |                               |                                     |
| 49   | NDE - radiography and hydro test   | 1   | lot | \$ 1,500.00      | \$ 1,500.00          |                               |                                     |
| 50   | installation   | 1   | day | \$ 1,500.00      | \$ 1,500.00          |                               |                                     |
| 51   | <u>Other Mechanical</u>  |     |     |                  |                      |                               |                                     |
| 52   | HP tubing protection covers  | 2   | ea. | \$ 600.00        | \$ 1,200.00          |                               | estimate                            |
| 53   | signage  | 1   | ea. | \$ 1,500.00      | \$ 1,500.00          |                               | estimate - Jenmar recent experience |
| 54   | installation labor   | 0.5 | day | \$ 1,500.00      | \$ 750.00            |                               | estimate                            |
| 55   |  |     |     | <b>Subtotal:</b> | <b>\$ 34,156.00</b>  |                               |                                     |
| 56   | <b>Electrical Work</b>   |     |     |                  |                      |                               |                                     |
| 57   | wiring to fill posts   | 1   | lot | \$ 6,000.00      | \$ 6,000.00          |                               | estimate                            |
| 58   | wiring to light poles  | 1   | lot | \$ 4,000.00      | \$ 4,000.00          |                               | estimate                            |
| 59   | equipment bonding and grounding - matl and labor   | 1   | lot | \$ 6,000.00      | \$ 6,000.00          |                               | estimate                            |
| 60   | installation of 500 KVA transformer  | 1   | ea. | \$ 75,000.00     | \$ 75,000.00         |                               | allowance                           |
|      | civil work for electrical service installation, trench, installation of duct boxes, conduit, backfilling, counterpoise cable and secondaries, wire and final tie-ins, concrete slab for substation foundation and installation, supply and install |     |     |                  |                      |                               |                                     |
| 61   | power meter  | 1   | lot | \$ 15,000.00     | \$ 15,000.00         |                               | allowance                           |
| 62   | conduit and wiring to gas dryer  | 1   | lot | \$ 6,000.00      | \$ 6,000.00          |                               | allowance                           |
| 63   | transfer switch  | 1   | lot | \$ 25,000.00     | \$ 25,000.00         |                               |                                     |
| 64   | electrical permit  | 1   | ea. | \$ 1,100.00      | \$ 1,100.00          |                               |                                     |
| 65   | freight costs and tool rental  | 1   | lot | \$ 3,000.00      | \$ 3,000.00          |                               |                                     |
| 66   |  |     |     | <b>Subtotal:</b> | <b>\$ 141,100.00</b> |                               |                                     |
| 67   | <b>Equip Shipping</b>  |     |     |                  |                      |                               |                                     |
| 68   | equipment shipment - IMW to site   | 1   | ea. | \$ 35,000.00     | \$ 35,000.00         |                               | Estimate                            |
| 69   |  |     |     | <b>Subtotal:</b> | <b>\$ 35,000.00</b>  |                               |                                     |
| 70   | <b>Approvals &amp; Permits</b>   |     |     |                  |                      |                               |                                     |
| 71   | pressure equipment design reviews  | 1   | lot | \$ 600.00        | \$ 600.00            | NS TSD                        | Estimate                            |
| 72   | gas permit   | 1   | ea. | \$ 1,000.00      | \$ 1,000.00          | NS TSD                        | Estimate                            |
| 73   | electrical permit  | 1   | ea. | \$ 1,100.00      | \$ 1,100.00          | NS TSD                        |                                     |
| 74   | field inspections  | 3   | ea. | \$ 1,000.00      | \$ 3,000.00          | NS TSD                        | Estimate                            |
| 75   | building permit  | 1   | ea. | \$ 2,000.00      | \$ 2,000.00          | TBD if required               | Estimate                            |
| 76   | ERCB environmental study - fugitive emissions and noise  | 1   | ea. | \$ 15,000.00     | \$ 15,000.00         | TBD if required               | WAG if required                     |
| 77   |  |     |     | <b>Subtotal:</b> | <b>\$ 22,700.00</b>  |                               |                                     |
| 78   | <b>Engineering PM &amp; Admin</b>  |     |     |                  |                      |                               |                                     |
| 79   | EPC civil engineering - concrete slab design   | 1   | ea. | \$ 5,000.00      | \$ 5,000.00          | Jenmar Concepts               | estimate                            |
| 80   | grading design   | 1   | ea. | \$ 12,000.00     | \$ 12,000.00         |                               |                                     |
| 81   | land survey  | 1   | ea. | \$ 5,000.00      | \$ 5,000.00          |                               |                                     |
| 82   | geotechnical survey  | 1   | ea. | \$ 8,000.00      | \$ 8,000.00          |                               | estimate                            |
| 83   | site inspection  | 1   | ea. | \$ 1,200.00      | \$ 1,200.00          | Jenmar Concepts               | estimate                            |
| 84   | EPC Engineering and drawings   | 1   | lot | \$ 90,000.00     | \$ 90,000.00         |                               | estimate                            |
| 85   | system/process engineering   | 32  | hr  | \$ -             | \$ -                 | Jenmar Concepts               |                                     |
| 86   | equipment specifications preparation/purchase support  | 16  | hr  | \$ -             | \$ -                 | Jenmar Concepts               |                                     |
| 87   | purchase/supplier follow-up/management   | 12  | hr  | \$ -             | \$ -                 | Jenmar Concepts               |                                     |
| 88   | misc equipment and material RFQs   | 12  | hr  | \$ -             | \$ -                 | Jenmar Concepts               |                                     |
| 89   | supplier equipment design reviews  | 8   | hr  | \$ -             | \$ -                 | Jenmar Concepts               |                                     |
| 90   | plot plan  | 24  | hr  | \$ -             | \$ -                 | Jenmar Concepts               |                                     |

| Item | Description   | Qty | UOM | Cost                | Subtotal               | Contractor           | Notes                     |
|------|---|-----|-----|---------------------|------------------------|----------------------|---------------------------|
| 91   | HP line sizing  | 6   | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 92   | field electrical conduit sizing and routing                 | 4   | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 93   | equipment bonding and grounding design                      | 4   | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 94   | electrical equipment specifications - single line diagrams  | 6   | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 95   | buried piping design and routing                            | 12  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 96   | field CNG piping diagrams                                   | 12  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 97   | equipment approvals management                              | 16  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 98   | misc brackets, rails, etc.                                  | 20  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 99   | signage design  | 4   | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 100  | as-built drawings   | 24  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 101  | approval documentation                                      | 20  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 102  | EPC project management and other engineering                | 85  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 103  | factory acceptance testing (FAT) and report                 | 12  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 104  | development of operating procedures and training            | 16  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 105  | development of emergency response plan (ERP) and training   | 24  | hr  | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 106  | field inspection - trip to site                             | 2   | day | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 107  | field commissioning and training trip                       | 3   | day | \$ -                | \$ -                   | Jenmar Concepts      |                           |
| 108  | Owner Project Management and Administration                 | 1   | lot | \$ 50,000.00        | \$ 50,000.00           | Owner                | estimate                  |
| 109  |   |     |     | <b>Subtotal:</b>    | <b>\$ 171,200.00</b>   |                      |                           |
| 110  | <b>Travel &amp; Accommodations</b>                          |     |     |                     |                        |                      |                           |
| 111  | budget for travel, airfares, accommodation, rental vehicles | 1   | lot | \$ 6,000.00         | \$ 6,000.00            |                      |                           |
| 112  |   |     |     | <b>Subtotal:</b>    | <b>\$ 6,000.00</b>     |                      |                           |
| 113  | <b>Site Supervision &amp; Commissioning</b>                 |     |     |                     |                        |                      |                           |
| 114  | construction Supervision - site                             | 20  | day | \$ 1,400.00         | \$ 28,000.00           |                      |                           |
| 115  | Equipment commissioning services                            | 1   | lot | \$ 11,000.00        | \$ 11,000.00           | IMW (Chilliwack, BC) | Estimate<br>IMW quotation |
| 116  |   |     |     | <b>Subtotal:</b>    | <b>\$ 39,000.00</b>    |                      |                           |
| 117  |   |     |     | <b>TOTAL</b>        | <b>\$ 1,606,701.00</b> | no contingency       |                           |
|      |   |     |     | Contingency         | 10%                    |                      |                           |
|      |   |     |     | \$                  | <b>160,670.10</b>      |                      |                           |
|      |   |     |     | <b>GRAND TOTAL:</b> | <b>\$ 1,767,371.10</b> |                      |                           |

**JENMAR CONCEPTS**  
Consulting Engineers  
**TURN-KEY DE-CANTING STATION BUDGET**



Owner: TBD  
Project: Phase 2 - CNG De-Canting Station  
Prepared by: Mark Epp  
Date: March 7, 2012  
Doc. No.: QN-0006-01  
Revision: 00

**Assumptions and comments**

1. Costs based on owner issuing purchase orders direct to suppliers/contractors
2. Costs do not include risk or profit
3. Based on typical site plan
4. Does not include cost of land. Assumes land is developed with utilities
5. No costs for land grading, gravel or asphalt included
6. No chain link fencing, site grading/gravel or lighting included
7. Electrical service costs are rough estimates.
8. Dual train PRS
9. Customer connection flange short distance from PRS

| Item | Description   | Qty | UOM | Cost                | Subtotal             | Contractor  | Notes   |
|------|---|-----|-----|---------------------|----------------------|---|---|
| 1    | <b>Equipment</b>  |     |     |                     |                      |   |   |
| 2    | Pressure Reduction System - IMW 1500-250-4                              | 1   | ea. | \$ 117,200.00       | \$ 117,200.00        | IMW (Chilliwack, BC)  | IMW quotation   |
| 3    | Dual Train Option   | 1   | ea. | \$ 45,000.00        | \$ 45,000.00         |   |   |
| 4    | De-Canting Posts - Single Hose  | 2   | ea. | \$ 4,800.00         | \$ 9,600.00          |   |   |
| 5    |   |     |     | <b>Subtotal:</b>    | <b>\$ 171,800.00</b> |   |   |
| 6    | <b>Civil Work</b>   |     |     |                     |                      |   |   |
| 7    | concrete slab for PRM - 8' x 5' x 8" thick                              | 1   | ea. | \$ 4,000.00         | \$ 4,000.00          |   | quote<br>estimate from recent job<br>estimate from recent job<br>estimate from recent job |
| 8    | concrete slab for HCM - 6' x 4' x 8" thick                              | 1   | ea. | \$ 3,200.00         | \$ 3,200.00          |   |   |
| 9    | fill post footings  | 2   | ea. | \$ 1,000.00         | \$ 2,000.00          |   |   |
| 10   | concrete blocks   | 32  | ea. | \$ 110.00           | \$ 3,520.00          |   |   |
| 11   | concrete block delivery and installation                                | 32  | ea. | \$ 75.00            | \$ 2,400.00          |   |   |
| 12   | offloading and equipment placement                                      | 1   | ea. | \$ 500.00           | \$ 500.00            |   |   |
| 13   | trenching for electrical conduits for power to equipment and light pold | 60  | ft  | \$ 140.00           | \$ 8,400.00          |   |   |
| 14   | shelter roof for PRM and HCM  | 2   | ea. | \$ 2,000.00         | \$ 4,000.00          |   |   |
| 15   |   |     |     | <b>Subtotal:</b>    | <b>\$ 8,900.00</b>   |   |   |
| 16   | <b>Mechanical Work</b>  |     |     |                     |                      |   |   |
| 17   | HP gas line materials - de-canting post (2 lines)                       |     |     |                     |                      |   | recent quotes   |
| 18   | 1" x .109 316SS tube - ASTM A213 TP316SS                                | 60  | ft  | \$ 28.00            | \$ 1,680.00          |   |   |
| 19   | tube fittings   | 1   | lot | \$ 1,500.00         | \$ 1,500.00          |   |   |
| 20   | brackets and support/installation                                       | 1   | lot | \$ 1,500.00         | \$ 1,500.00          |   |   |
| 21   | installation labor  | 2   | day | \$ 1,000.00         | \$ 2,000.00          |   |   |
| 22   | hydro testing   | 0.5 | day | \$ 1,000.00         | \$ 500.00            |   |   |
| 23   | equipment rental  | 1   | lot | \$ 200.00           | \$ 200.00            |   |   |
| 24   | Low Pressure Gas Line - PRM to boiler                                   |     |     |                     |                      |   |   |
| 25   | 1" pipe and fittings  | 1   | lot | \$ 200.00           | \$ 200.00            |   |   |
| 26   | installation  | 1   | day | \$ 1,000.00         | \$ 1,000.00          |   |   |
| 27   | support brackets and covers   | 1   | lot | \$ 1,500.00         | \$ 1,500.00          |   |   |
| 30   | Water/glycol lines - PRM to boiler                                      |     |     |                     |                      |   |   |
| 31   | 2" pipe and fittings  | 1   | lot | \$ 250.00           | \$ 250.00            |   |   |
| 32   | installation  | 1   | day | \$ 1,000.00         | \$ 1,000.00          |   |   |
| 33   | support brackets and covers   | 1   | lot | \$ 1,500.00         | \$ 1,500.00          |   |   |
| 34   | <b>Other Mechanical</b>   |     |     |                     |                      |   |   |
| 35   | HP tubing protection covers   | 2   | ea. | \$ 600.00           | \$ 1,200.00          | estimate<br>estimate - Jenmar recent experience<br>estimate |   |
| 36   | signage   | 1   | ea. | \$ 1,500.00         | \$ 1,500.00          |   |   |
| 37   | installation labor  | 0.5 | day | \$ 1,500.00         | \$ 750.00            |   |   |
| 38   |   |     |     | <b>Subtotal:</b>    | <b>\$ 16,280.00</b>  |   |   |
| 39   | <b>Electrical Work</b>  |     |     |                     |                      |   |   |
| 40   | equipment bonding and grounding - matl and labor                        | 1   | lot | \$ 1,000.00         | \$ 1,000.00          |   | estimate<br>allowance<br>allowance  |
| 41   | electrical power connection   | 1   | lot | \$ 1,500.00         | \$ 1,500.00          |   |   |
| 42   | wiring to de-canting post   | 1   | lot | \$ 1,000.00         | \$ 1,000.00          |   |   |
| 43   | disconnect switch   | 1   | lot | \$ 800.00           | \$ 800.00            |   |   |
| 44   | electrical permit   | 1   | ea. | \$ 500.00           | \$ 500.00            |   |   |
| 45   | freight costs and tool rental   | 1   | lot | \$ 200.00           | \$ 200.00            |   |   |
| 46   |   |     |     | <b>Subtotal:</b>    | <b>\$ 5,000.00</b>   |   |   |
| 47   | <b>Equip Shipping</b>   |     |     |                     |                      |   |   |
| 48   | equipment shipment - IMW to site  | 1   | ea. | \$ 5,000.00         | \$ 5,000.00          |   | Estimate  |
| 49   |   |     |     | <b>Subtotal:</b>    | <b>\$ 5,000.00</b>   |   |   |
| 50   | <b>Approvals &amp; Permits</b>  |     |     |                     |                      |   |   |
| 51   | pressure equipment design reviews                                       | 1   | lot | \$ 600.00           | \$ 600.00            | NS TSD  | Estimate  |
| 52   | gas permit  | 1   | ea. | \$ 500.00           | \$ 500.00            | NS TSD  | Estimate  |
| 53   | electrical permit   | 1   | ea. | \$ 300.00           | \$ 300.00            | NS TSD  | Estimate  |
| 54   | field inspections   | 2   | ea. | \$ 500.00           | \$ 1,000.00          | NS TSD  | Estimate  |
| 55   | building permit   | 1   | ea. | \$ -                | \$ -                 | TBD if required   | Estimate  |
| 56   |   |     |     | <b>Subtotal:</b>    | <b>\$ 2,400.00</b>   |   |   |
| 57   | <b>Engineering PM &amp; Admin</b>                                       |     |     |                     |                      |   |   |
| 58   | EPC Engineering, drawings, project management, approval                 | 1   | lot | \$ 35,000.00        | \$ 35,000.00         | Owner   | estimate<br>estimate  |
| 59   | Owner Project Management and Administration                             | 1   | lot | \$ 10,000.00        | \$ 10,000.00         |   |   |
| 60   |   |     |     | <b>Subtotal:</b>    | <b>\$ 45,000.00</b>  |   |   |
| 61   | <b>Travel &amp; Accommodations</b>                                      |     |     |                     |                      |   |   |
| 62   | budget for travel   | 1   | lot | \$ -                | \$ -                 |   |   |
| 63   |   |     |     | <b>Subtotal:</b>    | <b>\$ -</b>          |   |   |
| 64   | <b>Site Supervision &amp; Commissioning</b>                             |     |     |                     |                      |   |   |
| 65   | construction Supervision - site   | 10  | day | \$ 1,400.00         | \$ 14,000.00         |   | Estimate<br>combined with mother station commissioning                                    |
| 66   | Equipment commissioning services  | 2   | day | \$ 3,000.00         | \$ 6,000.00          |   |   |
| 67   |   |     |     | <b>Subtotal:</b>    | <b>\$ 20,000.00</b>  |   |   |
| 68   |   |     |     | <b>GRAND TOTAL:</b> | <b>\$ 274,380.00</b> | no contingency  |   |

Contingency 10%  
\$ 27,438.00  
**GRAND TOTAL: \$ 301,818.00**



# **APPENDIX C**

## **Process Calculations Spreadsheets**

# CASE STUDY CALCULATIONS

## QUEST NS PHASE 2

| Parameter                            | Value                | Unit                  |
|--------------------------------------|----------------------|-----------------------|
| <b>Cast I.D.</b>                     |                      |                       |
| <b>FACTORS AND CONSTANTS</b>         |                      |                       |
| natural gas heating value            | 38.5                 | MJ/m <sup>3</sup> HHV |
| natural gas heating value            | 1.09                 | MJ/scf                |
| natural gas density at S.T.P.        | 0.722                | kg/m3                 |
| gasoline heating value               | 34.84                | MJ/liter              |
| <b>LOGISTICS STUDY</b>               |                      |                       |
| <b>MOBILE STORAGE SPECIFICATIONS</b> |                      |                       |
| manufacturer                         | Fiba Canning         |                       |
| description                          | 14 tube tridem jumbo |                       |
| cylinder specification               | DOT 3AA-2750+        |                       |
| number of cylinders                  | 14                   |                       |
| total water volume                   | 1220                 | ft <sup>3</sup>       |
| total water volume                   | 34547                | liters                |
| Module weight                        | 41000                | Kg                    |
| <b>Full Conditions</b>               |                      |                       |
| full pressure                        | 19060                | kPa                   |
| full pressure                        |                      | Bar                   |
| full pressure                        | 2750                 | psig                  |
| temperature                          | 288                  | °K                    |
| temperature                          | 15                   | °C                    |
| density                              | 178.1                | kg/m3                 |
| Gas weight                           | 6152                 | Kg                    |
| <b>Loaded Road weight</b>            | <b>47152</b>         | <b>Kg</b>             |
| <b>Max Road Weight</b>               | <b>41500</b>         |                       |
| <b>Empty Conditions</b>              |                      |                       |
| empty pressure                       | 1500                 | kPa                   |
| empty pressure                       | 203                  | psig                  |
| temperature                          | 288                  | °K                    |
| temperature                          | 15                   | °C                    |
| density                              | 11.0                 | kg/m3                 |
| <b>Energy Transferred</b>            |                      |                       |
| total CNG transferred per delivery   | 7992.0               | Sm <sup>3</sup>       |
| total CNG transferred per delivery   | 282234               | scf                   |
| energy transferred                   | 308                  | GJ HHV                |

### CUSTOMER LOAD PROFILE

|                            |         |                 |
|----------------------------|---------|-----------------|
| annual consumption         | 350000  | GJ HHV/yr       |
| cost of fuel               | \$ 5.50 | /GJ HHV         |
| travel distance (one-way)  | 75      | km              |
| average travel speed       | 60      | km/hr           |
| process load duration      | 52.0    | weeks           |
| peak load                  | 2365    | GJ/day          |
| peak load                  | 1506    | scfm            |
| average load               | 962     | GJ/day          |
| average load               | 612     | scfm            |
| no. of deliveries per year | 1138    |                 |
| no. of deliveries per day  | 3.13    |                 |
| total load per day         | 24975   | Sm <sup>3</sup> |
| total load per day         | 881985  | scf             |

### MOTHER STATION PERFORMANCE

|                                     |        |           |
|-------------------------------------|--------|-----------|
| station load                        | 350000 | GJ HHV/yr |
| station volume                      | 881993 | scf       |
| supply gas pressure                 | 800    | psig      |
| no. of compressors available        | 2      |           |
| compressor flow per unit            | 928    | scfm      |
| total compressor flow               | 1856   | scfm      |
| no. of compressors operating        | 1      |           |
| trailer filling rate                | 928    | scfm      |
| fueling time per mobile storage     | 5.1    | hours     |
| compressor operating time per day   | 15.8   | hours     |
| compressor operating hours per year | 5766   | hours     |
| compressor duty cycle               | 69%    |           |
| redundancy                          | 100%   |           |

### OPERATIONS TIME STUDY

#### Trailer Use Time

| Parameter   | Unit       |
|---|------------|
| connect nozzle/unhitch empty trailer for filling (mother) | 15 min     |
| filling duration  | 304 min    |
| hitch/disconnect nozzle from full trailer (mother)        | 15 min     |
| travel time to client site                                | 75 min     |
| connect nozzle/unhitch full trailer (de-canting)          | 15 min     |
| de-canting time   | 461 min    |
| hitch/disconnect nozzle from empty trailer (de-canting)   | 15 min     |
| travel to mother station                                  | 75 min     |
| extra margin time   | 120 min    |
| total de-canting time                                     | 7.7 hours  |
| total transport time                                      | 10.6 hours |
| total minimum cycle time                                  | 18.2 hours |
| actual cycle time   | 23.8 hours |
| trailer idle time   | 5.6 hours  |
| minimum no. of trailers required                          | 3          |

**Labor Time**

|   |     |       |
|---|-----|-------|
| connect nozzle/unhitch empty trailer for filling (mother) | 15  | min   |
| hitch/disconnect nozzle from full trailer (mother)        | 15  | min   |
| travel time to client site                                | 75  | min   |
| connect nozzle/unhitch full trailer (de-canting)          | 15  | min   |
| hitch/disconnect nozzle from empty trailer (de-canting)   | 15  | min   |
| travel to mother station                                  | 75  | min   |
| extra margin time   | 120 | min   |
| total labor input per delivery                            | 5.5 | hours |

**OPERATIONS COST****MOTHER STATION****Maintenance Cost**

|  |                      |            |
|--|----------------------|------------|
| compressor type                                    | electric             |            |
| station security remote monitoring                 | \$ 18,000.00         |            |
| fixed yearly cost for operator                     | \$ 55,000.00         |            |
| fixed yearly cost for maintenance                  | \$ 25,000.00         |            |
| incremental maintenance cost per unit              | \$ 0.016             | per gle    |
| incremental maintenance cost per unit              | \$ 0.416             | per GJ HHV |
| monthly maintenance cost                           | \$ 14,204.55         |            |
| yearly maintenance cost                            | \$ <b>243,454.55</b> |            |
| maintenance cost per unit compressed               | \$ 0.696             | per GJ HHV |
| maintenance cost per unit compressed operator cost | \$ 0.024             | per gle    |

**Natural Gas Engine Fuel Consumption**

|                               |         |           |
|-------------------------------|---------|-----------|
| gas engine brake horsepower   | 0.00    |           |
| fuel consumption rate         | 11.00   | MJ/bkW-hr |
| fuel unit cost                | \$ 5.50 | \$/GJ HHV |
| monthly fuel cost             | \$ -    |           |
| annual fuel cost              | \$ -    |           |
| fuel cost per unit compressed | \$ -    | \$/GJ     |

**Electrical Costs**

|                                    |            |           |
|------------------------------------|------------|-----------|
| main drive motor                   | <b>150</b> | hp        |
| main motor efficiency              | 92%        |           |
| main motor load                    | 163.0      | hp        |
|                                    | 121.6      | kW        |
| gas cooling fan motors             | 10.00      | hp        |
| engine cooling radiator fan motors | 0.00       | hp        |
| fan motor efficiency               | 88%        |           |
| cooling fan motor load             | 11.36      | hp        |
|                                    | 8.48       | kW        |
| gas dryer regen load               | 16.91      | kW        |
| electric heater load               | 15.00      | kW        |
| block heater                       | 0.50       | kW        |
| control power                      | 2.00       | kW        |
| other loads                        | 2.00       | kW        |
| max demand                         | 149.61     | kW        |
| power factor                       | 0.90       |           |
| max demand                         | 166.23     | KVA       |
| electricity usage per day          | 2374       | kWh/day   |
| electricity usage month            | 72004      | kWh/month |

|  |                      |                 |
|--|----------------------|-----------------|
| electricity usage per year                               | 864044               | kWh/annum       |
| utility name   | NS Power             |                 |
| tariff category  | Small Industrial     |                 |
| demand charge rate                                       | \$ 6.85              | /mo-kVA         |
| max demand energy charge rate                            | \$ 0.08965           | /kWh            |
| energy charge rate                                       | \$ 0.06848           | /kWh            |
| load factor  | 67%                  |                 |
| demand side cost recovery raider (DCRR)                  | \$ 0.00415           | /kWh            |
| fuel adjustment mechanism (FAM)                          | \$ 0.00324           | /kWh            |
| demand charge per month                                  | \$ 1,139.35          | per month       |
| max demand energy charge                                 | \$ 2,980.52          | per month       |
| energy charge  | \$ 4,917.11          | per month       |
| DCRR charge  | \$ 298.82            | per month       |
| FAM charge   | \$ 233.29            | per month       |
| total electric costs per month                           | \$ 9,569.09          | per month       |
| total electric costs per annum                           | \$ 114,829.02        | per annum       |
| cost per kWh   | \$ 0.133             | /kWh            |
| electric cost per unit compressed                        | \$ 0.33              | per GJ HHV      |
| <b>Total O&amp;M Estimate</b>                            | <b>\$ 358,283.57</b> | per annum       |
| total O&M per unit                                       | <b>\$ 1.02</b>       | per GJ HHV      |
| <b>CNG TRANSPORT</b>                                     |                      |                 |
| number of axles  | 4                    |                 |
| maintenance cost per axle                                | \$ 0.025             | per km per axle |
| trailer maintenance per unit travelled                   | \$ 0.10              | per km          |
| annual trailer maintenance cost                          | \$ 17,062.55         | per annum       |
| trailer/cylinder requalification testing (very 10 years) | \$ 1,000.00          | per annum ea.   |
| maintenance per unit                                     | \$ 0.057             | per GJ HHV      |
| rolling rate for transport                               | \$ 3.40              | per km          |
| non-rolling rate for transport                           | \$ 80.55             | per hr          |
| travel distance  | 150                  | kms             |
| non-rolling time   | 180                  | min             |
| <b>Total Cost To Deliver (per load)</b>                  | \$ 751.65            |                 |
| total deliery costs per year                             | <b>\$ 875,167.02</b> |                 |
| total operations cost per unit                           | <b>\$ 2.50</b>       | per GJ HHV      |
| <b>DE-CANTING STATION</b>                                |                      |                 |
| <b>Maintenance Estimate</b>                              |                      |                 |
| routine service visits per year                          | 52                   |                 |
| unschedule maintenance hours                             | 4                    |                 |
| hours per visit  | 1.0                  |                 |
| labor hourly rate  | \$ 100.00            | \$/hr           |
| unschedule maintenance cost                              | \$ 400.00            |                 |
| spare parts budget                                       | \$ 5,000.00          | \$/yr           |
| schedule maintenance and service cost                    | \$ 5,200.00          |                 |
| total maintenance cost                                   | \$ 10,600.00         |                 |
| cost per unit of fuel delivered                          | \$ 0.030             | \$/GJ           |
| <b>Natural Gas Fuel Consumption</b>                      |                      |                 |
| percent of throughput used for heating                   | 0.5%                 |                 |
| total fuel used annually for heating                     | 1,750                | GJ HHV/yr       |
| total cost of fuel gas delivery                          | \$ 4.26              | \$/GJ           |

|   |    |                  |             |
|---|----|------------------|-------------|
| cost of unprocessed fuel gas            | \$ | 5.50             | \$/GJ       |
| total cost of fuel gas consumed         | \$ | 17,085.80        |             |
| cost per unit fuel delivered            | \$ | 0.049            | \$/GJ       |
| <b>Electrical Cost</b>                  |    |                  |             |
| pump horsepower                         |    | 2                | HP          |
| power factor                            |    | 0.93             |             |
| motor efficiency                        |    | 80%              |             |
| motor power                             |    | 1.87             | kW          |
| control power                           |    | 1.00             | kW          |
| total power consumption                 |    | 2.87             | kW          |
| max demand (kW)                         |    | 2.87             |             |
| max demand (kVA)                        |    | 3.08             |             |
| process duration                        |    | 52               | weeks       |
| total power consumption (kW-hr/mo)      |    | 2086             |             |
| total power consumption (kW-hr/yr)      |    | 25029            | kW-hr/annum |
| utility name                            |    | NS Power         |             |
| tariff category                         |    | Small Industrial |             |
| demand charge rate                      | \$ | 6.85             |             |
| max demand energy charge rate           | \$ | 0.08965          |             |
| energy charge rate                      | \$ | 0.06848          |             |
| load factor                             |    | 99.7%            |             |
| demand side cost recovery raider (DCRR) | \$ | 0.00415          |             |
| fuel adjustment mechanism (FAM)         | \$ | 0.00324          |             |
| demand charge per month                 | \$ | 19.64            |             |
| max demand energy charge                | \$ | 55.24            |             |
| energy charge                           | \$ | 129.13           |             |
| DCRR charge                             | \$ | 8.66             |             |
| FAM charge                              | \$ | 6.76             |             |
| total electric costs per month          | \$ | 219.42           |             |
| total electric costs per annum          | \$ | <b>2,633.04</b>  |             |
| cost per kWh                            | \$ | 0.105            |             |
| cost per unit fuel delivered            | \$ | 0.008            | \$/GJ       |
| <b>Total O&amp;M Estimate</b>           | \$ | <b>30,318.84</b> |             |
|   | \$ | <b>0.087</b>     | \$/GJ       |
| <b>CAPITAL COST RECOVERY</b>            |    |                  |             |
| cost of money                           |    | 6.0%             |             |
| number of annuities (years to recover)  |    | 20               |             |
| capital cost recovery factor            |    | 0.087            |             |
| <b>MOBILE STORAGE EQUIPMENT</b>         |    |                  |             |
| capital cost per mobile storage         | \$ | 400,000.00       |             |
| number of trailers required             |    | 3                |             |
| capital cost for all trailers           | \$ | 1,200,000.00     |             |
| annual cost                             | \$ | 104,621.47       |             |
| cost per fuel unit                      | \$ | <b>0.30</b>      | \$/GJ       |
| <b>MOTHER STATIONS</b>                  |    |                  |             |
| capital cost for station                | \$ | 1,767,371.00     |             |
| annual cost                             | \$ | 154,087.46       |             |
| cost per fuel unit                      | \$ | <b>0.44</b>      | \$/GJ       |
| <b>DE-CANTING STATION</b>               |    |                  |             |
| capital cost for station                | \$ | 303,468.00       |             |
| annual cost                             | \$ | 26,457.72        |             |
| cost per fuel unit                      | \$ | <b>0.08</b>      | \$/GJ       |

**GAS DISTRIBUTION PIPELINE**

|                                      |    |              |       |
|--------------------------------------|----|--------------|-------|
| capital cost for distribution system | \$ | 1,575,000.00 |       |
| annual cost                          | \$ | 137,315.68   |       |
| cost per fuel unit                   | \$ | <b>0.39</b>  | \$/GJ |
| <b>Fuel Cost Summary</b>             |    |              |       |
| fuel cost                            | \$ | <b>5.50</b>  | \$/GJ |
| total O&M cost                       | \$ | <b>3.61</b>  | \$/GJ |
| total capital recovery costs         | \$ | <b>1.21</b>  | \$/GJ |
| <b>Total Delivered Cost</b>          | \$ | <b>10.32</b> | \$/GJ |