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OPERATIONS AND SAFETY COMMITTEE

MONDAY, MAY 11, 2015, 8:00 A.M.
OMNITRANS METRO FACILITY
1700 WEST 5TH STREET
SAN BERNARDINO, CA 92411

The meeting facility is accessible to persons with disabilities. If assistive listening devices or other auxiliary aids or Limited English Proficiency services are needed in order to participate in the public meeting, requests should be made through the Recording Secretary at least three (3) business days prior to the Committee Meeting. The Recording Secretary's telephone number is 909-379-7110 (voice) or 909-384-9351 (TTY), located at 1700 West Fifth Street, San Bernardino, California. If you have comments about items on the agenda or other general concerns and are not able to attend the meeting, please mail them to Omnitrans at 1700 West Fifth Street, San Bernardino, California, Attention Board Secretary. Comments may also be submitted by email to BoardSecretary@omnitrans.org.	
A. CALL TO ORDER	
1. Pledge of Allegiance	
2. Roll Call	
B. ANNOUNCEMENTS/PRESENTATIONS	
1. Next Committee Meeting: Not scheduled at this time.	
C. COMMUNICATIONS FROM THE PUBLIC	
This is the time and place for the general public to address the Board for items that are not on the agenda. In accordance with rules applicable to meetings of the Operations and Safety Committee, comments on items not on the agenda and on items on the agenda are to be limited to a total of three (3) minutes per individual.	
D. POSSIBLE CONFLICT OF INTEREST ISSUES	
Disclosure – Note agenda items contractors, subcontractors and agents, which may require member abstentions due to conflict of interest and financial interests. Board Member abstentions shall be stated under this item for recordation in the appropriate item.	N/A
E. DISCUSSION ITEMS	
1. Approve Operations and Safety Committee Minutes – September 10, 2014	2
2. Recommend the Board of Directors Receive and File Final Summary Report, Liquefied Natural Gas (LNG) Operations Risk Assessment	5
3. Recommend the Board of Directors Receive and File Final Report, Compressed Natural Gas (CNG) Fueling Infrastructure Feasibility Study and Approve Recommendation to Proceed with Developing Preliminary Design, Technical Specifications and Solicitation Documents with "On Call" Architect and Engineering Firm	58
F. REMARKS AND ANNOUNCEMENTS	
G. ADJOURNMENT	

Posted: May 6, 2015

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1700 W. Fifth St.
San Bernardino, CA 92411
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ITEM # E1

OPERATIONS AND SAFETY COMMITTEE
MINUTES
SEPTEMBER 10, 2014

A. CALL TO ORDER

The Operations and Safety Committee Meeting was called to order by Committee Chair Sam Spagnolo at 9:00 a.m., Wednesday, September 10, 2014.

1. Pledge of Allegiance
2. Roll Call – Self-Introductions

Committee Members Present
Mayor Pro Tem, Sam Spagnolo – Committee Chair
Mayor Ray Musser, City of Upland
Supervisor Gary Ovitt, County of San Bernardino
Supervisor James Ramos, County of San Bernardino
Council Member Dick Riddell, City of Yucaipa
Council Member John Roberts, City of Fontana
Mayor Pro Tem Alan Wapner, City of Ontario

Committee Members Not Present
Supervisor Josie Gonzales, County of San Bernardino
Mayor Pro Tem Ed Palmer, City of Rialto

Omnitrans Administrative Staff Present
Scott Graham, CEO/General Manager
Diane Caldera, Director of Operations
Jack Dooley, Director of Maintenance
Marjorie Ewing, Director of Human Resources
Samuel Gibbs, Director of Internal Audit
Jacob Harms, Director of Information Technology
Andres Ramirez, Construction Manager
Jennifer Sims, Director of Procurement
Don Walker, Director of Finance
Wendy Williams, Director of Marketing
Mark Crosby, Loss Prevention Supervisor
Ross Hrinko, Safety & Regulatory Compliance Specialist

B. ANNOUNCEMENTS/PRESENTATIONS

There were no announcements.

C. COMMUNICATION FROM THE PUBLIC

There were no communications from the public.

D. POSSIBLE CONFLICT OF INTEREST ISSUES

There were no conflict of interest issues identified.

E. DISCUSSION ITEMS

1. Approve Operations and Safety Committee Meeting Minutes – July 1, 2014

   M/S (Wapner/Musser) that approved the Committee Minutes of July 1, 2014. Motion was unanimous by Members present.

2. Recommend to Board of Directors, Award Contract SAS14-241, LNG Operations Risk Assessment, Award Contract FIN14-269, Compressed Natural Gas (CNG) Fueling Infrastructure Feasibility Study, and Take No Further Action on RFP-ADM14-268, Remote Fueling Study

   CEO/General Manager Scot Graham presented the three recommendations before the Committee for consideration and briefly discussed the history of CNG Fuel at Omnitrans dating back to 1998, including the transition from CNG to LNG (Liquefied Natural Gas) in 2002, as a result of concerns raised by the surrounding community. Mr. Charles Love of Clean Energy was introduced and presented information comparing new technology available using pipeline gas with the technology that existed prior to 2002, touching on the following topics:

   - Similar Projects—Four projects in Southern California face similar density challenges and are located directly next to neighbors (Two at LA Metro locations, Montebello Transit and San Diego), and none have received any complaints regarding odors coming from the station.
   - New Technology/Safety Measures—No odor is vented into the atmosphere. The new system includes a surrounding skid that has several safety mechanisms in place that will shut the system down immediately, including safeguards in the event of an earthquake, lack of power to the station, and quality issues. The pipeline gas is the same that feeds into residences, and is on-demand; therefore no storage tanks are required. It is the same pipeline structure used by Southern California Gas (SoCal Gas). Based on the amount of sensors in place, the system would shut down if gas odor was detected and would not be released into the atmosphere.
   - Anatomy of a CNG Fuel Station —The Montebello Transit CNG Fuel Station was featured and Mr. Love walked Members through the anatomy of a station. Omnitrans could consider installing an optional sound barrier, similar to what LA Metro and San Diego has done, as an added measure to be good neighbors.

- Renewable Natural Gas – Omnitrans could also consider using renewal natural gas from Clean Energy, which is farmed and redeemed from methane gas fields. Harmful greenhouse gases are captured, run through a filtration system, and is the cleanest natural gas available.
- Committee Members questioned whether the SoCal Gas pipeline coming onto Omnitrans' property has sufficient pressure to fuel the buses, what transmission fees are charged by SoCal Gas, and what the return on investment is for returning to pipeline gas.

  Mr. Love explained that these questions will be addressed in the feasibility study and CEO/General Manager Graham stated that capital funds to convert back to pipeline gas would have to be identified and operational costs would be reduced.

Committee Chair Spagnolo, as well as Board Chair Wapner and Member Ramos, thanked the community for bringing their concerns to the Board of Directors. By doing so, it provided an opportunity for Omnitrans' to look at its existing system and the new technology available for consideration by the Board of Directors.

M/S/ (Musser/Ramos) to recommend to the Board of Directors, authorize the CEO/General Manager to award Contract SAS14-241 to Kazarians & Associates of Glendale, CA, in the amount of $49,590, plus a 10% contingency of $4,959; for a total not-to-exceed amount of $54,549, for the provision of an LNG Operations Risk Assessment on Existing Omnitrans Fueling Facilities; and

Authorize the CEO/General Manager to award Contract FIN14-269 to Clean Energy of Seal Beach, CA, in the amount of $30,200, plus a 10% contingency of $3,020, for a total not-to-exceed amount of $33,220; for the provision of a Compressed Natural Gas (CNG) Fueling Infrastructure Feasibility Study to evaluate switching from LNG to pipeline natural gas and removing existing LNG tanks, and

Authorize that no further action be taken on RFP-ADM14-268, Remote Fueling Study, as no responses to the solicitation were received. Motion was unanimous by Members present.

F. Remarks and Announcements

There were no remarks or announcements.

G. Adjournment

The Operations and Safety Committee adjourned at 9:40 a.m. The next Committee Meeting will be scheduled and posted at Omnitrans and on the Omnitrans website.

Prepared by:

____
Christine Vega, Administrative Secretary

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ITEM # E2

DATE: May 11, 2015

TO: Committee Chair Sam Spagnolo and
Members of the Operations and Safety Committee

THROUGH: P. Scott Graham, CEO/General Manager

FROM: Marjorie Ewing, Director of Human Resources & Safety Regulatory Compliance

SUBJECT: **LIQUEFIED NATURAL GAS (LNG) OPERATIONS RISK ASSESSMENT**

FORM MOTION

Recommend the Board of Directors receive and file the final summary report on the Liquefied Natural Gas (LNG) Operations Risk Assessment.

BACKGROUND

On October 1, 2014, the Board authorized the CEO/General Manager to award Contract SAS14-241 to Kazarians & Associates of Glendale, CA, in the amount of $49,590, plus a 10% contingency of $4,959; for a total not-to exceed amount of $54,549, for the provision of an LNG Operations Risk Assessment Study.

The scope of work for the study includes three (3) major tasks:

Task 1: Municipal Codes Review: Identify Applicable Codes; Assess Compliance; Develop Findings; and Propose Mitigation Plans & Alternative for Findings.

Task 2: Earthquake Risk/Impact: Identify industry standards; Assess Compliance with Standards; Review seismic zone 4 and equate to Richter Scale (for magnitude); Propose Mitigation Plans & Alternatives or Findings.

Task 3: Risk Review: Define properties of natural gas, LNG/CNG; Identify Risks & Associated Hazards; Assess Physical/Structural Integrity of Underground Storage Tanks, Vault, and Dispensing System as it pertains to the unlikely event of a catastrophic explosion; Propose Mitigation Plans & Alternatives for Findings.

RESULTS OF THE LIQUEFIED NATURAL GAS (LNG) OPERATIONS RISK ASSESSMENT STUDY

Slide presentation presented by Mardy Kazarians, Kazarians & Associates, Inc.

The study concluded that we are in compliance with regulations. There are suggestions over and beyond what is required, which Omnitrans would consider implementing.

CONCLUSION

Staff recommends the Committee receive and forward to the Board of Directors for receipt and file of the final summary report and slide presentation on the Liquefied Natural Gas (LNG) Operations Risk Assessment.

PSG: ME

Kazarians & Associates, Inc.

LNG Operations Risk Assessment

Prepared for:

OmniTrans

San Bernardino, California

Prepared by:

Kazarians & Associates, Inc.
Glendale, California 91210

May 2015
K&A Ref. No.5404.150506

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EXECUTIVE SUMMARY

OmniTrans operates a public transit bus refueling station in the City of San Bernardino that uses Liquefied Natural Gas (LNG) to fuel buses with Compressed Natural Gas (CNG). OmniTrans has selected Kazarians & Associates, Inc. to conduct an LNG Operations Risk Assessment with the specific objectives of:

- Ensure compliance with safety and regulatory requirements.
- Review of seismic aspects of the systems
- An assessment of the probability of an explosive atmosphere
- Identification of potential ignition sources
- A quantitative analysis of accident scenarios that includes small releases
- The probability and consequences of the explosion
- Study whether a hazardous or non-hazardous area exists at the fueling site.

The codes and standards that apply to LNG fueling stations are reviewed. A large number of standards were in effects when the original LNG storage, pumping and vaporization systems were designed and constructed. Since then, they have been consolidated into NFPA 52, which addresses LNG storage and fueling systems. In this study, the systems are reviewed against the current requirements and it is concluded that in general terms the systems comply with NFPA 52 requirements. There are only a few hardware related differences between the design and current NPFA 52 requirements. The balance of the differences relate to administrative issues that are partly met by current practices.

The seismic ruggedness of the systems is also reviewed in this study. The standard that was used at the time of design is compared with current standards and it is concluded that the margin of safety used in the original design well covers the new requirements. Additionally, a system walk-down was conducted. From that direct observation of the physical systems a few recommendations are proposed to improve seismic safety of the storage and handling systems.

A risk analysis is conducted to address OmniTrans objectives on the possibility of explosion, presence of ignition sources and consequences of a release. As part of the risk analysis, a set of potential release scenarios are identified. The hazard zone of each scenario is estimated, and for those that can extend outside the facility boundary, probability of occurrence is estimated. Scenarios are identified by using a well-established method that is commonly used in the chemicals processing and petroleum refining industries. The scenarios obtained from that analysis is further refined through the application of event trees where various potential conditions that can influence the hazard zone are included in the model. A wide range of scenarios are identified that includes small and large releases depending on the specific conditions of the event. For example, a flange failure is expected to lead to a small release, while hose break when unloading a truck is expected to lead to a large release.

Several computer programs were examined for estimating the shape and dimensions of potential hazard zones. *Phast* computer program was selected for this study since it offers the most sophisticated features that model release of LNG. Hazard zone computations take into account release conditions (e.g., liquid release and evaporation), formation of a gas cloud, and ignition leading to jet fire, pool fire and flash fire. The possibility of a severe storage tank explosion due to exposure to fire (also known as BLEVE in the industry) and vapor cloud explosion are examined, and it is concluded that neither pose a credible threat outside of this facility. However, several scenarios are concluded to have an impact outside the facility boundary through thermal radiation.

Scenario probabilities are also estimated in this study using failure probabilities and human error rates provided in various industry sources. The hazard zones are divided into two categories: (1) potential for injury and (2) severe injury with the possibility of fatality if the exposed person is unable to self-evacuate. The total probabilities of the two hazard categories are concluded to be once per 3,500 years and once per 47,000 years, respectively. These probabilities demonstrate that offsite impact of LNG operation at OmniTrans facility is a rare event, which is also corroborated by the industry experience. From a review of industry events since mid-1940s, none of the reported LNG release events has adversely affected public safety. These probabilities are deemed to be conservative given the uncertainties in the hazard zone modeling and that event probability sources tend to report probability values conservatively. From a study of scenario probabilities and hazard zones it is also concluded that 95% of potential injury scenarios may extend up to 880 feet from the facility boundary and 95% scenarios with the potential for severe injury may extend up to 175 feet from the facility boundary.

As a final note, it may be added that the objective of this study does not include a determination regarding acceptable levels of risk associated with LNG storage and handling systems. This study is an attempt to provide sufficient information to all stakeholders to allow them to arrive at their own conclusions. There is no regulatory requirement for OmniTrans to modify any of its current practices, and that this study did not discover any significant safety deficiencies. However, based on direct inspection of the physical systems, observations of LNG receiving operations, review of current OmniTrans practices and review of current codes and standards, suggestions for improvements are recommended for OmniTrans management's consideration.

1.0 INTRODUCTION AND SCOPE

OmniTrans operates a public transit bus refueling station in the City of San Bernardino that uses Liquefied Natural Gas (LNG) to fuel buses with Compressed Natural Gas (CNG). OmniTrans has selected Kazarians & Associates, Inc. to conduct an LNG Operations Risk Assessment with the specific objectives of:

- Assess the probability of an explosive atmosphere and identification of potential ignition sources at the East Valley storage and fueling site.
- Conduct a quantitative analysis that will provide a detailed study of accident scenarios due to small releases of gas from the facility, and the probability/consequences of the explosion as compared to other types of fuels.
- Study whether a hazardous or non-hazardous area exists at the fueling site.
- Review and assess the storage tanks and related operations to ensure compliance with safety and regulatory requirements.

To achieve the last objective, municipal codes and related standards are reviewed and the seismic aspects of the LNG facility are studied.

In this study, the various aspects of LNG storage and bus fueling operations are analyzed from the safety perspective. The design and established practices are compared with industry standards and practices. Recommendations are proposed to improve the systems and related operations based on analysts' experience and comparisons with industry practices.

The objective of this study does not include a determination regarding acceptable levels of risk associated with LNG storage and fueling operation. This report will attempt to provide sufficient information to all stakeholders to allow them to arrive at their own conclusions.

In this report, compliance with applicable standards is addressed first. Seismic aspects of the system are discussed next. The balance of this report is focused on the potential for an accidental release and extent of hazard zones.

2.0 PHYSICAL PROPERTIES OF LNG AND CNG

Natural gas is a term used to refer to a mixture of hydrocarbon components that is typically obtained from oil-wells. Greater than 95% of it is methane. Minor components of natural gas include ethane, propane, butane, pentane and nitrogen. Therefore, natural gas properties are very close to those of methane, which are used in this study where data for natural gas was not available.

The boiling point of natural gas is approximately -259°F (-161°C). In order to maintain natural gas as Liquefied Natural Gas (LNG), it must be subjected to either very high pressure or very low temperature. At OmniTrans, LNG is maintained at low temperature in insulated storage vessels.

When released into the atmosphere, LNG vaporizes rapidly by absorbing heat from its surroundings. Vaporized LNG forms a very cold vapor cloud of natural gas that mixes with air as wind blows through it. The density of cold natural gas vapor is greater than that of air. Therefore, in the initial stages of LNG release, its vapors stay close to ground. However, as it absorbs heat its density decreases reaching its ambient level which is much lighter than air. At this stage, natural gas rises and dissipates into higher elevations. At ambient temperature, liquid natural gas will expand up to 600 times its initial volume upon vaporization.

Natural gas is a flammable substance that when released into the atmosphere it has the potential to form a combustible vapor cloud. If its concentration in the air is within flammable range (i.e., 5% to 15% by volume for methane), it may combust in the presence of an ignition sources. Otherwise, the mixture in air is either too rich [i.e., above upper flammable limit (UFL), 15%] or too lean [i.e., below lower flammable limit (LFL), 5%].

In addition to fire hazard, the low boiling point of LNG presents safety concerns of exposure to a cryogenic material. Also, rapid vaporization of LNG can displace air and pose asphyxiation hazard.

Properties of LNG are further discussed in Appendix A.

3.0 SYSTEMS INCLUDED IN THE ANALYSIS

This study addresses the following elements of the LNG storage and handling related systems and operations:

- Storage tanks and all the equipment located within the Storage Vault
- Vaporizers
- Buffer tanks and related valving and controls
- Fuel dispensers
- LNG truck unloading operation

LNG truck unloading operation includes truck movement within the site. Fuel dispensers are included for the potential for inadvertent relief valve opening and dispensing hose failure. Bus fueling operation (e.g., improper hose connection to a bus), however, is not included in this study.

4.0 COMPLIANCE WITH CURRENT STANDARDS

The LNG storage and handling systems were originally designed in 2001 and construction was completed by 2002. Since that time, the bus fueling section of the systems has been modified. This includes relocation of the buffer tanks and control valves, relocation of fuel dispensing stations, and the addition of a third fuel dispenser. The design of the modifications was completed in 2012 and construction will be completed in 2015.

The design of all system components and related structures complies with the codes and standards in effect at the time of design (i.e., 2001 for LNG storage tanks, pumps and vaporizer and 2012 for the fuel dispensers.). A variance was issued for storage tank placement. The codes in effect in 2002 required that the LNG storage tanks be installed outside. The regulation also stated that the Storage Tanks must be at least 50 feet from the nearest property. Due to the close proximity of the Storage Tanks to the fence line, OmniTrans was granted a variance from the Occupational Safety and Health Standards Board, allowing the Storage Tanks to be located in their current position under the condition that they be enclosed in a containment vault [OSHSB, 2005].

At the time of the original system design a large number of codes and standards had to be met. Under current conditions, the primary code to which an LNG fueling system must comply with is NFPA 52 that has brought together under one document standards that apply to the design, installation, operation, and maintenance of compressed natural gas (CNG) and liquid natural gas (LNG) to CNG facilities, in which LNG is stored in ASME containers of 70,000 gallons or less. Applicable portions of the following publications are referenced within NFPA 52, and they have therefore been implicitly incorporated as a part of this evaluation:

National Fire Protection Association

- NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages, 2012 Edition
- NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines 2010 edition
- NFPA 51B, Standard for Fire prevention During Welding, Cutting, and Other Hot Work, 2009 edition
- NFPA 54, National Fuel Gas Code, 2012 edition
- NFPA 59A, Production, Storage, and Handling of Liquefied Natural Gas (LNG), 2013 edition
- NFPA 70, "National Electrical Code", 2011 Edition
- NFPA 80, Standard for Fire Doors and Other Opening Protectives, 2013 edition
- NFPA 259, Standard Test Method for Potential Heat of Building Materials, 2013 edition

- NFPA 496, Standard for Purged and Pressurized Enclosures for Electrical Equipment, 2013 edition.
- NFPA-5000, Building Construction and Safety Code, 2012 edition

American Petroleum Institute

- API 620, Design and Construction of Large, Welded, Low Pressure Storage Tanks, 1996

American Society of Civil Engineers

- ASCE Minimum Design Loads for Buildings and Other Structures, 2010

American Society of Mechanical Engineers

- ANSI/ASME B31.3, Process Piping, 2004
- ASME Boiler and pressure Vessel Code, Section VIII, X, 2004

ASTM International

- ASTM A 47/A47M, Standard Specification for Ferritic Malleable Iron Casting, 1999 (2009).

American National Standards Institute (ANSI)

- ANSI/NGV 1, Standard for Compressed Natural Gas Vehicle Fueling Connections Devices
- ANSI/NGV 4.1, NGV Dispensing Systems
- ANSI/NGV 4.2, Hoses for Natural Gas Vehicles and Dispensing Systems
- ANSI/NGV 4.4, Breakaway Devices for Natural Gas Dispensing Hoses and Systems
- ANSI/NGV 4.6, Manually Operated Valves for Natural Gas Dispensing Systems
- ANSI/NGV 4.7, Automatic Pressure Operated Valves for Natural Gas Dispensing Systems

American Society of Mechanical Engineers (ASME)

- Boiler and Pressure Vessel (B&PV) Code)
  - Section V - Nondestructive Examination
  - Section VII, Division 1 - Pressure Vessels
  - Section IX - Welding and Brazing Qualifications
- ASME A13.1, Scheme for the Identification of Piping Systems
- ASME B16.25, Buttwelding Ends

- ASME B31.3, Process Piping

American Society for Nondestructive Testing (ASNT)

- SNT-TC-1A Recommended Practice

American Welding Society (AWS)

- A5.1 Covered Carbon Steel Arc Welding Electrodes
- A5.5 Low Alloy Steel Covered Arc Welding Electrodes

In addition to combining the different standards, NFPA 52 includes several revisions that have been made since 2006. The 2006 edition of NFPA 52 was a complete revision, which incorporated NFPA 57 "LNG Vehicular Fuel Systems Code" into NFPA 52. Additionally, the scope of the standard was expanded to include hydrogen, and new chapters were added that addressed general gaseous hydrogen requirements and equipment qualifications; service and maintenance of gaseous hydrogen engine fuel systems; gaseous hydrogen compression, gas processing, storage, and dispensing systems; and liquefied hydrogen fueling facilities.

The 2010 edition of NFPA 52 includes revisions that mostly address hydrogen related issues and improves the coordination between this standard and NFPA 55.

In the 2013 revision of NFPA 52 hydrogen systems related requirements are removed and transferred to NFPA 2. A chapter on general fueling requirements was added to NPFA 52, and changes were made to the onboard gas detection requirements for LNG-fueled vehicles. The installation requirements for ASME Tanks for LNG were updated to coordinate with NFPA 59A.

In this study, the design and operation of LNG storage and handling systems are reviewed against NFPA 52 requirements to gain an understanding of the differences between systems design and current requirements. Appendix B provides a list of the relevant requirements of that standard along with a statement addressing level of compliance. Overall, with the exception of one clause requiring a deflector, system design is in compliance with current NFPA 52 requirements. According to Clause 10.2.1.8 of NFPA 52 deflectors should be installed where there is a possibility of horizontal accidental release of LNG. All other non-compliant clauses address administrative requirements. For example, clause 7.3.13.1. requires a periodic hazard analysis of the systems. Recommendations are provided to OmniTrans to consider incorporating these requirements in their current operations and safety procedures and policies. These recommendation are further discussed in the conclusions section of this report.

5.0 SEISMIC VULNERABILITY

The seismic vulnerability review focused on the following issues:

- Compliance with current applicable standards
- Seismic zone 4 review and its relationship with the Richter Scale
- Potential mitigation plans and alternatives

Industry Standards
The design standards for the LNG storage and handling systems is comparable to standards applicable to the chemical plants and refineries. The seismic design standards for these type of facilities are currently based on the International Building Code [IBC, 2012], California Building Code [CBC, 2013] and ASCE/SEI 7-10 Minimum Design Loads for Building and Other Structures [ASCE, 2013]. These standards and building codes replaced the Uniform Building Code standards. Based on the documentation provided, the standards used in the design of LNG storage and handling systems was based on Uniform Building Code 1997 [UBC, 1997] which was the building code in force at the time of the design of the facility.

Compliance with Current Standards
The available plans and documents for the existing Storage Vault and LNG storage tanks and piping were reviewed for compliance with various standards. The following notes summarize the observations and findings:

- The existing LNG storage tanks and piping and the Storage Vault are designed based on [UBC, 1997]. The bus fueling (dispensers) and maintenance facility and the building that houses these systems are designed later and are based on [CBC, 2010] building and the codes in force at the time of design.
- The Storage Vault and related equipment and piping are deigned based on the requirements of Seismic Zone 4, which required the design to consider a minimum acceleration of 0.6006g. This acceleration level is greater than that of current requirements based on [CBC 2013] and [ASCE, 2013] for OmniTrans Facility location. Therefore, the original design used much stricter conditions than what is required today.

Seismic Hazard
A seismic hazard analysis typically involves the consideration of all ground faults that may affect the facility. An analysis had been done on soil and geology aspects of the site ([Byerly, 1989] and [Ninyo, 1997]) that addresses seismicity of the site. These reports conclude that the underlying soil of OmniTrans facility is suitable for the buildings and the facility currently constructed at this site. Underground water was not detected in the test borings (max depth 51.5ft). Therefore, the site is not susceptible to liquefaction and seismically induced settlement.

Ground faults that traverse near the facility are identified and analyzed for effective peak horizontal accelerations in [Ninyo, 1997] and [Byerly, 1989]. Effective peak horizontal accelerations is the bases for building codes used by structural engineers for design purposes. According to [Ninyo, 1997] and [Byerly, 1989], San Jacinto Fault, which is located less than one mile from the facility, may produce the largest, 0.47g, effective peak horizontal acceleration at OmniTrans Facility. Since, in the original design 0.6006g and in the current additions 0.484g have been used, the design of LNG storage and handling systems is expected to withstand seismic activities generated by nearby faults.

Potential Mitigation Plans and Alternatives

Based on a site observation walkthrough, the following should be studied further:

- Anchorage and foundation of the Vaporizer to verify its seismic design basis
- The LNG pipe connection to the northerly site property line retaining and fence wall to verify that pipe connections to the wall meet seismic design conditions.
- The northerly site property line retaining wall and fence wall to verify its seismic design basis
- The two LNG pipe penetrations through the northerly wall of the Storage Vault and their connections to the Vaporizers to verify that the pipe can flex under seismic load applied to the building and the Vaporizers
- Clearance between the emergency exit stair landing and the LNG storage tanks to verify that landing structure would not collide with the nearest LNG Storage Tank outer shell.

6.0 OVERALL APPROACH FOR ASSESSEING LNG OPERATIONS RISK

The overall analysis approach is described in this section. While this section describes the general approach used in this study, the specifics of each part of the approach are provided in the sections that follow.

Risk is defined as the answer to the following three questions [CCPS, 2008]:

- What can go wrong?
- How likely is it?
- What would be the consequences?

A collection of the answers to these three questions can characterize the risk of a system or operation. The information obtained can be manipulated in many different ways to obtain metrics most useful to the users of the study. In this study, release scenarios that may impact the public outside facility boundaries are identified, and their likelihoods are estimated.

For the purposes of this study, the first question of risk analysis process (i.e., what can go wrong) is focused on potential release scenarios of LNG or CNG. To identify these scenarios, a systematic method, guideword-style Hazard and Operability (HAZOP), is employed to minimize the chance that an important scenario is missed. This methodology is commonly used in the chemicals processing and petroleum refining industries to evaluate safety risk. Additionally, industry events relevant to LNG storage and handling were reviewed to verify that the identified release scenarios capture those incidents.

The scenarios identified by HAZOP methodology are further refined by applying the Event Tree Analysis (ETA) methodology, where additional conditions are introduced. For example, time of ignition affects the outcome of the event. If an ignition source is present close to the release point, the event may be limited to a pool fire. If the ignition source is located further down-wind, there could be a potential for flash fire.

The consequences of each scenario are estimated in terms of hazard zones. Hazard zone is defined as the specific area on the ground where a person may receive harm. Harm is defined as exposure of the public outside of facility boundaries to fire or explosion conditions. Exposure to extreme cold caused by an LNG spill or asphyxiation because of displacement of air are only possible within a very short distance of an LNG spill. Therefore, these two phenomena are not addressed as concerns for the public outside the facility. These two phenomena present safety concerns to OmniTrans personnel only, and are addressed through their internal safety programs.

The chain of events following a release leading up to a harmful condition on the ground may involve multitudes of complex phenomena. They may involve such phenomena as LNG release from a narrow opening, liquid evaporation, dispersion of gas cloud, formation of a flammable mixture and heat flux generated by a fire after ignition. Depending on the type of phenomena, different computational methods are employed to estimate the parameters of these conditions with final goal of estimating the shape and extent of ensuing hazard zone.

The likelihood or probability of each scenario depends on the initiating event of the scenario, and other conditions that may need to be in place for a certain hazard condition to be realized. For example, hose failure is an initiating condition that would cause spill of LNG on the ground outside the Storage Vault. The quantity of LNG spilled will depend on the time of emergency valve shutoff activated by the truck driver. Probability values of each event are estimated using industry and other relevant sources.

7.0 RELEASE SCENARIO ANALYSIS

7.1 Selection and Basis of the Scenario Identification Methodology

The guideword-style Hazard and Operability (HAZOP) methodology [CCPS, 2008] augmented with the "what-if" questioning process is employed to identify potential release scenarios[1]. This methodology was developed in the chemicals process industry and is now extensively used in process and refining industries to analyze safety risk of various systems and operations and is widely accepted by regulatory agencies. The methodology provides a systematic approach necessary to ensure that almost all important scenarios identified.

This method employs a pre-selected set of parameters and guidewords to facilitate a thought process for identifying potentially hazardous situations or operating problems. Automatic and manual operations (e.g., receiving LNG) of the system are analyzed using the HAZOP study approach. Special conditions and outside influences on the system are analyzed using the "what-if" approach.

The HAZOP methodology is based on the premise that each component or segment of a system has a specific design intent, and a deviation from this intent may lead to a hazardous condition. For example, an LNG Storage Tank is designed to contain a certain amount of fluid. Maintaining the liquid level within safe limits is a design intent of operating the vessel. If a vessel is overfilled (a deviation from the design intent) the pressure in the system may increase and a relief valve may lift to reduce the pressure. If the vessel level drops below a certain level (also a deviation), pump cavitation and operational problems may be experienced.

7.2 Summary of HAZOP Methodology

In a HAZOP study, the system is divided into nodes (segments, or process sections). The nodes may be selected based on the conditions of the effluents in the system. Typically, nodes are selected based on changes in the physical conditions of the effluent, that is, changes in pressure, temperature, composition, etc. Vessels, heat exchangers and pumping devices are typical points around which a node may be selected.

For each node, the design intent is specified. Based on the design intent, the parameters that describe various conditions of the node are identified. Parameters may include temperature, pressure, flow, composition, etc. Deviations are identified from the application of a standard set of guidewords to the parameters. For example, if the guideword "less" is applied to the parameter "level," the deviation "lower level" is achieved. Table 1 shows the standard set of guidewords [CCPS, 2008].

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[1] Generally, HAZOP studies in the process industry is conducted with the participation of a team familiar with the design and operation of the system. In this study, the analysis was conducted by the engineers at Kazarians & Associates, Inc. A similar study that had been conducted by Loss Control Associates, Inc. [Loss Control, 2001] was consulted. Kazarians analysis team also consulted with an engineer from NorthStar Engineering, who was involved in the construction of the system and continues to provide services. Additionally, Kazarians analysis team observed two LNG delivery operations.

Table 1 – Guide-words Used in the Identification of Parameter Deviations

Guide-word	Description	Example
No	Negation of the design intent	No flow
Less	Quantitative decrease	Low level
More	Quantitative increase	High pressure
Part of	Qualitative decrease	Part of step left out
As well as	Qualitative increase	Additional steps included
Reverse	Logical Opposite of the intent	Backflow
Other than	Complete substitution	Wrong material

In the course of this HAZOP study, every element of the system is reviewed and the appropriate design parameters identified. The list below gives a standard set of deviations used in this HAZOP study.

1. Low/No Flow
2. More Flow
3. Other than Flow (typically covers breaches in piping or vessels)
4. Misdirected Flow (typically covers inadvertent opening of valves because of human error)
5. Reverse Flow
6. High Level
7. Low level
8. High Pressure
9. Low Pressure
10. High Temperature
11. Low Temperature
12. Contaminants
13. What-If

In a HAZOP study, the applicable parameters and possibility of deviations are investigated for each node. If a cause can be identified for a deviation, the consequences of occurrence of that cause are established. To minimize the effort needed for a complete analysis of the system and to minimize double accounting of different scenarios, only those causes that can occur within the boundaries of a node are considered. Identified causes should be in terms of a well-defined event, equipment failure or human action (e.g., a normally closed valve is inadvertently opened, a fire occurs near a storage tank and a pump fails to start).

Consequences are the result of the deviation cause and may be expressed in terms of system condition, release of materials, effects on other equipment, deterioration of equipment, adverse effects on workers and the public, etc. When expressing the consequences of a deviation, no limits are imposed in terms of location and area. Consequence discussions are carried out until all possible adverse conditions are identified.

The possibility of occurrence of the cause of a deviation and severity of the consequences may be mitigated by existing system features, plant characteristics, and administrative controls (collectively referred to as safeguards). Existing safeguards are noted in the next step of HAZOP discussions. Safeguards include such features as relief devices, gas detectors, maintenance practices and operator training.

7.3 PHA Study Process and Results

Documents Reviewed

The following documents are used in the HAZOP study to define the system:

- "OmniTrans – San Bernardino, LCNG Transit Station, P&ID", Drawing 21003-20, Revision B, December 2001.
- "OmniTrans – San Bernardino, LCNG Transit Station, P&ID", Drawing 21003-20A, Revision B, December 2001.
- "OmniTrans – San Bernardino, LCNG Transit Station, P&ID", Drawing 21003-21, Revision B, December 2001.
- "OmniTrans – San Bernardino, LCNG Transit Station, P&ID", Drawing 21003-22, Revision B, December 2001.
- "OmniTrans – San Bernardino, LCNG Transit Station, P&ID", Drawing 21003-23, Revision B, December 2001.
- "LNG Offload Gas Monitoring Procedure", April 2003.
- "Process Hazard Analysis", LNG-CNG Fueling System, OmniTrans East Valley, April 2014.

The following documents and information sources were consulted to ensure that all accident scenarios discussed in them are addressed in the HAZOP study:

- "OmniTrans East Valley LNG – CNG Facility, San Bernardino, CA August 21 & 22, 2001", Process Hazard Analysis. Loss Control Associates, Inc. 2001.
- Industry Incidents Summary (see Appendix C)

Definition of the Nodes

The system is divided into the following nodes:

Node	Description
1	LNG Storage Tanks (V-100 and V-150)
2	LNG from LNG Storage Tank through LNG Pumps (P-200 or P-210) to Positive Displacement LNG Pumps (P-300, P-310, and P-320)
3	Positive Displacement LNG Pumps (P-300, P-310, and P-320) through liquid natural gas Vaporizers (H-400 or H-410)
4	CNG from Vaporizers to Buffer System and Dispensing
5	Truck offloading to LNG Storage Tanks (V-100 and V-150)

Assumptions

The analysis is based on the following assumptions:

- All maintenance contractors and vendor truck drivers are properly trained on their assigned tasks and industry accepted safe work practices.
- Since they are located inside the Pump Pots, loss of flow to a centrifugal LNG Pump would not lead to any leaks.
- The likelihood of a check valve to stick open is sufficiently small to not warrant consideration (note that check valves may leak but are very unlikely to cause a severe pressure boundary failure).

HAZOP Worksheets

The analysis is recorded in a standardized worksheet where the node, deviation, cause, consequence and safeguards are noted in separate columns. If a scenario leads to an adverse condition, a reference is added in the last column titled as "Further Analysis" directing the reader to other studies where the hazard zone of the scenario is estimated.

Appendix D provides a complete set of the HAZOP worksheets developed for this study. Figure 1 provides an example where three scenarios are included. The first scenario in Figure 1 describes a 1" pipe break that occurs outside the LNG Storage Vault upstream of the Vaporizer. This scenario is postulated in Node 3 as part of "Other than Flow" deviation. The entries in "Further Analysis" column refer to the event tree and hazard zone analysis cases associated with this scenario. Hazard zone analysis, as discussed later in this report, is based on the assumption that none of the safeguards are in place. Later when the likelihood of the scenario is estimated, failure probabilities of the safeguards are included in those computations. The second example refers to a drain valve left open due to operator error that leads to vapor release from the vent pipe above the roof line. Hazard zone analysis has concluded that the gas would disperse upwards and would not pose a hazard to the public. This is noted in the "Further Analysis" column and the analysis case is referenced.

Safeguards that are credited as a protection layer are prefaced with a "*" (protection layers are discussed in Section 7.4).

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HAZOP Worksheet

Node: 3. Positive Displacement LNG Pumps (P-300, P-310, and P-320) through liquid natural gas Vaporizers (H-400 or H-410)
Deviation: 3. Other than Flow
Drawings / References: 21003-20; 21003-20A; 21003-22
Equipment ID: P-300; P-310; P-320: Positive Displacement LNG Pumps

Cause	Consequence	Further Analysis	Effective Safeguards	Remarks
9. 1" pipe break on the liquid side outside the LNG Storage Vault due to internal causes	1. Potential for release of natural gas liquid outside. Potential for fire.	ET03_03 HP Liquid Spill 4	1. Mechanical Integrity Program 2. *PDP Pumps are equipped with a low pressure shutdown. 3. Natural gas detectors in the vault will alert personnel. 4. Foam suppression system can be activated to reduce thermal radiation.	

Node: 3. Positive Displacement LNG Pumps (P-300, P-310, and P-320) through liquid natural gas Vaporizers (H-400 or H-410)
Deviation: 4. Misdirected Flow
Drawings / References: 21003-20; 21003-20A; 21003-22
Equipment ID: P-300; P-310; P-320: Positive Displacement LNG Pumps

Cause	Consequence	Further Analysis	Effective Safeguards	Remarks
1. A drain valve upstream of the Positive Displacement LNG Pumps left open after maintenance	1. Release of natural gas liquid from the vent. Potential for fire.	No offsite consequences per Phast Runs "LP Liquid Venting 6" and "Storage Tank Spill 2"	1. Truck driver training and procedures.	

Node: 3. Positive Displacement LNG Pumps (P-300, P-310, and P-320) through liquid natural gas Vaporizers (H-400 or H-410)
Deviation: 10. Low Temperature
Drawings / References: 21003-20; 21003-20A; 21003-22
Equipment ID: P-300; P-310; P-320: Positive Displacement LNG Pumps

Cause	Consequence	Further Analysis	Effective Safeguards	Remarks
1. H-400 or H-410 Vaporizer fan failure due to internal causes	1. Decreased ability to vaporize liquid natural gas. Potential to send some liquid downstream of the vaporizers. Potential to expose the Priority Panel and Buffer Tanks to low temperature material. Potential for low temperature embrittlement that leads to fracture and failure. Release of natural gas liquid in the area. Potential for fire.	ET03_04 HP Liquid Spill 5	1. *TAL-400 or TAL-410 low temperature alarm and shutdown of PDP Pumps.	

Figure 1 – HAZOP Worksheet – An Example

8.0 HAZARD ZONES

8.1 Release and Dispersion Phenomena

Upon LNG or CNG release, a chain of events unfolds that depend on the release conditions, location of release, presence of an ignition source and weather condition. A multitude of complex thermodynamic phenomena dictate the outcome of the chain of events. Figure 2 provides a graphical representation of the various phenomena and their inter-relationships.

Each scenario starts with an accidental release. The parameters of interest in that part of the chain of events includes the phase (liquid or gas), release rate and total quantity released. Phase depends on the location of the breach in the system. For example, a hose break would result in a liquid release, while a pre-mature relief valve lift would release gas. The release rate depends on the phase, size of the opening and pressure behind the release point.

In case of liquid release, LNG will evaporate rapidly and form a dense cloud that will disperse by the wind. In this case, depending on the rate of release, a pool of LNG may form that will then evaporate and feed gas into the cloud. In case of gas release, the vapor would form a cloud upon release.

Location of an ignition source affects the size and shape of the hazard zone. If there is an ignition source near the release point (also known as *immediate ignition*), the material will ignite close to the source forming either a jet fire, pool fire, or both. A jet fire occurs when the material is released under pressure from an opening. If the ignition source is away from the release point, released gas would have an opportunity to form a flammable cloud as it is being pushed down the wind, that may then ignite leading either to an explosion or flash fire that would flash back to the source.

The hazard zone of released LNG and CNG, therefore, depends on the specific conditions of the release. In case of immediate ignition, the hazard zone would be determined by thermal radiation from the jet and pool fire. In case of delayed ignition, it would be determined by the size and shape of the gas cloud. In both cases, the hazard zone depends on the quantity of heat imparted onto a person standing on the ground. Table 2 represents the damage thresholds used in this analysis to determine the potential impact of public exposure to heat from a fire. Appendix E provides the bases of the threshold values selected for this study.

Table 1 – Thermal Radiation Exposure Thresholds

Thermal Radiation Flux	Impact
2 (kW/m^2)	Pain from exposure in 60 seconds
5 (kW/m^2)	Second degree burns in 60 seconds (minor injury in 30 seconds)
10 (kW/m^2)	Lethal in 60 seconds (possible fatality)

In the case of delayed ignition, weather condition has an important role in establishing the size and shape of the gas cloud that may remain within the flammable range. Air enters the gas cloud because of the turbulent effects of the wind and diffusion. Generally, low wind speeds are more stable and, therefore, the gas cloud would mix with air at a slower rate leading to a longer gas cloud within flammable concentration range. At higher wind speeds, the air is more turbulent, enhancing the mixing process. The net effect of this condition is a shorter distance where the gas cloud remains within its flammable range. Appendix F provides information about the weather patterns near the facility.

To estimate the hazard zone of a release, computational methods are needed that take into account the multitude of phenomena discussed above. Computerized method are needed for this purpose which are discussed below.

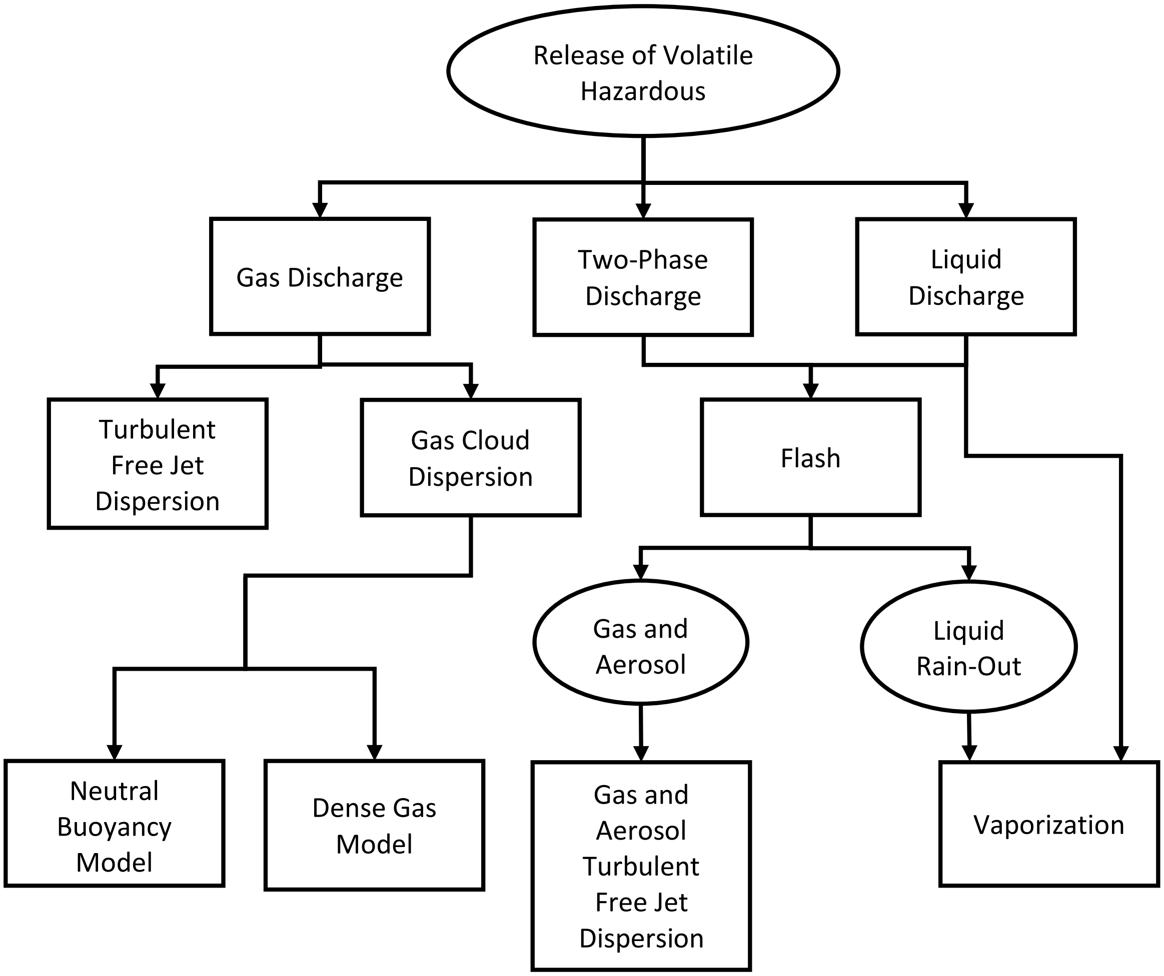


Figure 2 – Flow Chart of Release Phenomena
(Adopted from [CCPS, 1989])

8.2 Modeling Software

There are a large number of software packages currently available which can be used to model the release and dispersion characteristics for hazardous chemicals in industrial processes. Of these, several were designed with an emphasis on the dispersion characteristics of dense gases such as LNG. The most widely used models are ALOHA, RMP*Comp, the Dense Gas Dispersion Model (DEGADIS), SLAB, and Phast's Unified Dispersion Model (UDM). For the purposes of this report, Version 7.11 of Phast by Det Norske Veritas [DNV, 2015] was used as the primary modeling tool. Phast was chosen over ALOHA and RMP*Comp as the latter two programs are designed to provide over-conservative estimates for regulatory use. The simplistic models used by these programs result in large hazard footprints which are not necessarily accurate to the reality of a given scenario. Phast was also chosen over DEGADIS and SLAB, as these are only capable of modeling the concentration footprint for a given release, and cannot provide results for radiation due to fire or overpressure due to explosion. In addition, Phast's Unified Dispersion Model (UDM) has been approved by the US Department of Transportation

Pipeline and Hazardous Materials Safety Administration (PHMSA) for modeling of accidental releases of LNG [Quarterman, 2011].

Phast's UDM is able to provide results for discharge, dispersion, flammable, and explosive calculations for accidental releases of hazardous substances [Witlox, 2015]. In modeling a release from a vessel, Phast considers flashing of a liquid release into two-phase flow, condensation into liquid droplets, rainout, pool formation, and evaporation. Figure 3 provides a visual representation of the various aspects of a release as modeled by Phast [Shaba, 2013].

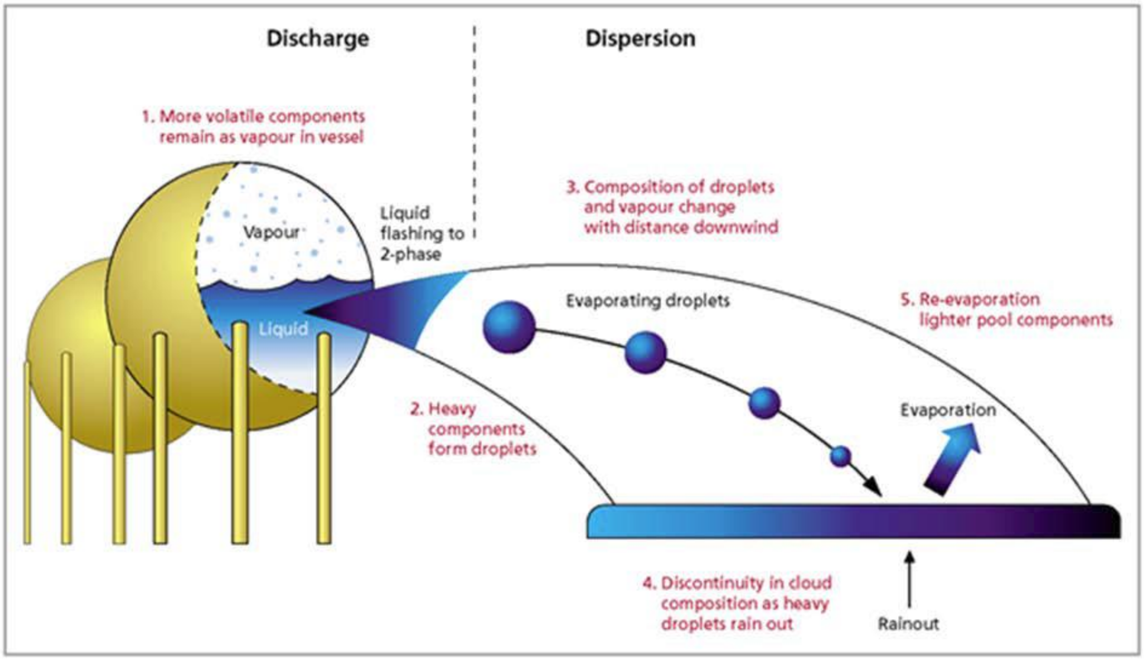


Figure 3 – Initial Stages of an Accidental Release as Modelled by Phast
(Adopted from [Shaba, 2013])

Following a release, Phast takes into account wind speed, ambient temperature, atmospheric stability, surface roughness, and other weather conditions in order to determine the behavior of the resultant vapor cloud as it travels downwind. In the case of flammable material such as LNG, Phast is able to calculate potential hazard zones based on thermal radiation due to a fire, or overpressure due to an explosion.

8.3 Scenario Definition

Following the scenario identification process, each potential release scenario from the HAZOP study is assigned to a release category. For example, in Figure 1 in *Further Analysis* column, "HP Liquid Spill 4" and "LP Liquid Venting 6" are two release categories assigned to the corresponding release scenarios. Since many of the scenarios in the HAZOP study lead to the same conditions, they are grouped into release categories that identifies the specific input parameters to be used with the modeling software. Each release category, along with the relevant Phast inputs and outputs, can be found in Appendix G.

It should be noted that based on variations in the process conditions which could impact the results some HAZOP scenarios may lead to more than one release category. For example, in Figure 1 “LP Liquid Venting 6” and “Storage Tank Spill 2” are assigned to the second scenario because in that scenario it is possible for an operator to close the drain valve upon noticing the spill on the roof. The first category (i.e., “LP Liquid Venting 6”) represents a release duration of 30 seconds and the second category (i.e., “Storage Tank Spill 2”) represents a continuous release until the affected storage is emptied. As another example, if a PSV on top of an LNG Storage Tank spuriously lifts, the liquid level in the Tank could be one third full, leading to an increased pressure release, or the Tank could be completely full, leading to a larger quantity of material released, but at a lower pressure. In this case, the spurious PSV lift identified in the HAZOP is tied to both “LP Vapor Venting 1” and “LP Vapor Venting 2” release categories for modeling purposes.

As discussed in the previous sections, following an accidental release of natural gas, ambient conditions have a significant impact on the dispersion of the resultant spill. Appendix F provides historical weather data for the San Bernardino area, which is used to define the weather conditions analyzed in this report. For each release scenario, three weather conditions are analyzed in terms of their ambient temperature, wind speed, and atmospheric stability class. Table 3 provides the weather inputs used in this analysis.

Table 3 – Weather Condition Definitions

Weather Condition	Category 1.5/F	Average Conditions	Santa Ana Conditions
Temperature (°F)	104	70	90
Wind Speed (m/s)	1.5	3.46	12
Atmospheric Stability	F	D	D
Percentage of Occurrence	39%	56%	5%

The first category, Category 1.5/F, is taken from the U.S. EPA’s guidance on defining conditions for a potential worst-case analysis [EPA, 2015], which states to use 1.5 m/s wind speed, an atmospheric stability class of F and the maximum recorded temperature over the previous five years. The Average and Santa Ana Conditions are defined using the historical data provided in Appendix F.

8.4 Time-Limited Releases

For many release scenarios presented in this analysis, there is a possibility that operators may intervene, or mechanical shutdowns will be able to activate, limiting the release to a specific duration. In these cases, two separate models are run in Phast, one in which the shutdown acts as designed, and the release is limited to a certain duration, and one in which no shutdown is activated, allowing the release to continue until the release source has been emptied. For the time-limited releases, a specific method must be used to allow for Phast to stop the release at a given time. For these events, the unlimited release case is run first, using the inputs displayed in Appendix G. From the unlimited release case, Phast allows the user to "Create Source," which creates a second scenario using the same release results calculated in the parent case. This new source can then be manually altered to allow the release to stop at the desired time.

8.5 Indoor Releases and Containment Size

Phast's modeling software includes a simplistic model for releases which occur inside a building, such as the LNG Storage Vault. The model is designed to determine the dispersion and ignition characteristics of the released material by assuming that the released material is able to perfectly mix with the air inside the building before being released [Xu, 2014]. The model requires input data on the building size, as well as ventilation characteristics. While this model works well for small release sizes, Phast is not reliable for rapid releases of large amounts of material. For example, in the case of a large liquid spill, the rate of vapor generation from the spill is greater than the rate at which the ventilation system can remove material from the building. In this event, Phast is unable to calculate the dispersion characteristics of the release.

For this analysis, the LNG Storage Vault is modeled as an 85.5 feet x 35 feet building, with a ventilation rate of approximately five air changes per hour when the ventilation is activated. In this analysis it is assumed that the combustible materials detectors within the building will activate the ventilation system upon release of LNG.

In addition, there are two containment areas defined within the building - the Pump Area and the Storage Tank Area. The Pump Area is defined as an area 22 feet by 35 feet, yielding a surface area of 770 square feet, as well as a height of 4.5 feet. The Storage Tank Area, which encompasses both the Pump Area and the raised Storage Tank Platform, is defined as an 85.5 feet x 35 feet space, giving a total surface area of 3,000 square feet. Because Phast does not allow multiple heights to be specified within one containment area, the height of the Storage Tank Area is defined as being between that of the Storage Tank platform and that of the Pump Area. Because the Storage Tank platform accounts for roughly 2/3 of the total surface area of the Vault, the bottom of the Storage Tank Area is assumed to be located at 2/3 of the height of the Pump Area, giving an overall height of 16 feet.

With this data, Phast is able to calculate the behavior of small releases within the LNG Storage Vault. Large releases, however, are unable to be modeled with Phast's current limitations. In guidance provided by DNV on indoor release modeling, Xu recommends that in the event that the release rate is greater than the ventilation rate, the model should be simulated as an outdoor release [Xu, 2014]. Additionally, because the evaporation rate is greater than the ventilation rate, pressure will rise in the LNG Storage Vault, building to the point that the roof vents will open (1 psi above atmospheric pressure), allowing the vapor cloud to enter the atmosphere directly. Therefore, for large indoor releases, dispersion modeling was performed as if the release took place outside.

8.6 Dispersion and Hazard Zones

Once a release has been properly defined, Phast will produce a series of graphs and reports detailing the dispersion characteristics for the particular scenario and weather condition. Downwind dispersion is displayed in terms of the maximum volumetric concentration of flammable material. In order for a release to ignite, it must be within the flammability range. That is, the ratio of flammable material to oxygen must be within a given range. As detailed in Appendix A, the flammability range of natural gas is taken to be between 5 to 15 volume percent in air. Outside these limits, the mixture is either too rich or too lean, which will not sustain combustion. However, due to the possibility of formation of flammable pockets within a vapor cloud due to mixing, as well as the uncertainties inherent in the dispersion model, Phast and PHMSA recommend that the flammable range be extended to 1/2 of the Lower Flammable Limit in order to form a more conservative picture of where ignition may occur [Quarterman, 2011]. For this study, 1/2 LFL is taken to be 2.5 volume percent.

If the release material ignited, there are five possible outcomes, depending on the ignition location (i.e., immediate and delayed ignitions). The possibilities are jet fire, pool fire, flash fire, Vapor Cloud Explosion (VCE), or BLEVE. A jet fire is caused when the material exiting the release point is under pressure and ignites, forming a flame pointing in the direction of the release. A pool fire occurs following a liquid spill, in which the liquid is allowed to pool prior to ignition, forming a large fire directly above the remaining liquid. Flash fire occurs when a vapor cloud is ignited in an unconfined area, causing the flammable material to burn rapidly before extinguishing. VCE and BLEVE are slightly more complex phenomena, and are described in detail in sections 8.7 and 8.8 below.

8.7 Possibility of Explosion

For an explosion to occur, a vapor cloud must ignite in a confined area. The increased confinement causes a corresponding increase in flame speed, which can result in a significant pressure wave. There are a number of models in Phast which may be used to determine the effect of a vapor cloud explosion, including the TNT method, the Multi-Energy method, and the Baker-Strehlow-Tang method. For this study, the Baker-Strehlow-Tang method was chosen over the TNT and Multi-Energy methods, as the latter two methods do not account for the low reactivity and flame speed of methane [Quest, 1999]. Additionally, the Multi-Energy method assumes a stoichiometric mixture of air and natural gas [Quest, 1999], which is an over-conservative assumption for this study.

In order to accurately determine the extent of the overpressure, the Baker-Strehlow-Tang method calculates the flame speed, which is calculated using five input parameters: degree of confinement, material reactivity, the effect of ground reflection, confined volume, and congestion.

Degree of confinement refers to the number of spatial dimensions to which the flame path is restricted. For example, ignition in open atmosphere would be classified as 3D, while an explosion between two buildings, in which the flame can only propagate upward or to the sides, would be considered 2D confinement. As the number of restricted dimensions increases, the flame speed and overpressure strength will increase accordingly, as the explosion energy will be funneled in only a few directions [Taveau, 2012]. As a conservative measure, all explosions in this study are modeled using 2D confinement.

Material reactivity can be classified as low, medium, or high, depending on the burning velocity of the gas being analyzed [Taveau, 2012]. Based on the work of Zeeuwen and Wiekema [Xu, 2014(a)], methane is classified as a low reactivity material, which results in a lower flame speed (and a correspondingly lower explosive potential) than heavier hydrocarbons such as propane and butane [Taveau, 2012].

Effect of ground reflection is used to determine the effect of the ground on the explosion force. That is, when an explosion happens near the ground or a similar surface such as the roof of a building, the downward force of the flame will be reflected upward by the surface, increasing the force of the blast in other directions. Phast recommends that for near ground explosions, the effect of ground reflection be set to a factor of 2 [Xu, 2014(a)].

Confined volume and *congestion* are parameters which can be calculated based on the area in which ignition occurs. Phast uses the same approach contained in the TNO Yellow Book [Xu, 2014(a)], which was written for the Multi-Energy method. The parameters are calculated for each obstructed region within the volume that could be occupied by the flammable release cloud. If there is more than one region, a composite value for each parameter is produced from the individual regional values. Once the volume has been defined, congestion is calculated as the ratio of the volume which is occupied by obstructions (e.g., storage tanks, buildings, or equipment) to the total confined volume. Congestion can be categorized as low, medium, or high, depending on the percentage of obstruction. Low congestion is defined as a blockage ratio of less than 10%, medium congestion is defined as between 10% and 40%, while high congestion is defined as a blockage ratio of greater than 40% [Taveau, 2012].

As an example, for releases occurring near the LNG Tanker Truck the confined volume is calculated as follows. The driveway around the Truck is partially confined by two parallel buildings that are 10 feet high and 59 feet apart. The buildings are less than 100 feet long. The other two sides of the driveway are block walls that are 8 feet tall and 450 feet apart. Within the driveway, the only obstruction is the Truck, which can be approximated by a horizontal cylinder 10 feet in diameter and 30 feet long. According to Phast, the obstructed region should be 1.5 times the diameter, or 15 feet vertically and 10 times the diameter, or 100 feet in length, except where the buildings impose a shorter length [Xu, 2014(a). This first obstruction region starts at grade, goes up 15 feet, across 59 feet, and lengthwise 100 feet, for a volume of 88,500 feet^3.

Within the obstructed region, the only obstruction volume is that of the truck, about 2,360 cubic feet, when modeled as a cylinder. The ratio of volumes is 2.67%, which falls in the low congestion level. Above this region, there is no obstruction or confinement.

Once the appropriate input parameters have been determined, Phast is able to calculate the strength of the pressure wave generated in the event of an explosion. In order to determine the hazard zone for an explosion event, damage thresholds have been defined to quantify the impact of an explosion on surrounding structures or people. Table 4 displays the damage thresholds used in this study, the bases of which may be found in Appendix E. Based on the computations done by Phast, it is concluded that for tall the scenarios considered, a vapor cloud explosion capable of generating the pressures presented in Table 3 is not credible. Therefore, any ignition of a vapor cloud will result in a flash fire as described in section 8.5.4 above.

Table 4 – Overpressure Exposure Thresholds

Maximum Overpressure	Impact
0.5 psi	Windows break (possible slight injuries)
2 psi	Structural damage to homes (possible injury or fatality)
5 psi	Homes destroyed (probable fatalities), eardrums ruptured

8.8 BLEVE

Boiling Liquid Expanding Vapor Explosion (BLEVE) is a well-known phenomenon in the chemical industry. BLEVE can occur when a storage tank containing liquid is exposed to an external heat source, such as being totally enveloped in a pool fire. In this case, the increased heat input from the fire causes the liquid to reach and exceed its boiling point and pressure in the tank to rise significantly. If the tank is equipped with a relief valve, the valve will open ejecting vapor to maintain tank pressure below its design limit. As vapor is released from the tank the liquid level will decrease leaving tank shell unprotected by the cooling effect of the liquid inside. The external heat source impinging on those parts of the tank that are no longer protected by the liquid inside may weaken the shell of the storage tank to the point of failure. Since the tank is under excess pressure, the weakened tank shell will rapidly propagate to a large break releasing tank contents. The liquid remaining in the tank, since it is well above its boiling point, will boil rapidly due to the sudden pressure drop, and the expansion of the resulting vapor can cause a large pressure wave. In addition, if the material inside the tank is flammable, the released material will ignite, resulting in a large fireball.

While a BLEVE event would have a large impact on the nearby population, the occurrence of such an event at the OmniTrans Facility is considered highly unlikely. The conditions necessary to cause a BLEVE are very specific. A large pool must form directly underneath the Storage Tank or Tanker truck, which, given the siting of the facility, requires a liquid leak in a specific location and in a specific direction. Following ignition, the fire must continue for a long enough duration to vaporize some of the material in the tank, as well as weaken both the outer and inner Tank shells. Even in the worst case, it can be concluded that there is not sufficient material in the Storage Tanks or Tanker truck to lead to a fire under these tanks long enough to cause BLEVE conditions. Therefore, such an event is considered to be of such a low likelihood as to not require further analysis.

8.9 Assumptions

To be able to estimate the hazard zones, it was necessary to make the following assumptions:

- In the event of a release during truck unloading, the driver or the standby OmniTrans employee will be able to recognize and respond to a loss of containment within 30 seconds. If they are unable to respond within that time, it is assumed that the release will continue until the truck empties.
- Similarly, in the event of a release when personnel are not immediately present, it is assumed that detection and response may take up to an hour, depending on personnel on site. If the release cannot be stopped within that time, it is assumed that the release will continue until the affected LNG Storage tank empties.
- The surface roughness factor is taken to be 1m, which is the recommended value for releases in an urban area [DNV, 2015].
- For the purposes of modeling high pressure LNG, the temperature of the material is assumed to be -118°F, as this is the maximum liquid temperature of methane before it becomes supercritical.
- Although the LNG Storage Vault floor is below street level, all releases in the vault are assumed to be at 0 feet, as Phast does not account for subterranean releases.
- For explosion modeling, areas of minimal congestion (e.g., the vent above the LNG Storage Vault) were assigned the default confined volume of 1 m^3.
- Ignition of a vapor cloud will result in a flash fire throughout the flammable area of the cloud. Due to the rapid nature of the flash fire, it is assumed that some injuries may occur if people are exposed to the flame, but it is highly unlikely to result in a fatal event.
- If a vapor cloud exits the LNG Storage Vault and ignites, it is assumed that the region of the cloud exiting the Vault will be too rich for flash back to ignite material remaining inside the Vault.

9.0 PROBABILITIES OF A HAZARDOUS EVENT

9.1 Event Tree Analysis Methodology

The scenarios defined by the HAZOP study are further refined through event trees to take into account special conditions (e.g., ignition time and system shutoff to limit quantity released). Event tree analysis is a technique in which all possible outcomes of a loss of containment event are examined in a systematic manner. Event trees are generally used to model chains of events or to identify the combinations of events that can take place after an event is initiated. In this study, event trees are used to identify the combinations of conditions that may affect the hazard zones and to compute probability of occurrence of the conditions that lead to a specific hazard zone.

The scenarios defined by the HAZOP study can be divided into six distinct types for the purposes of event tree analysis. These types are identified in Table 5. The number in the first column refers to the associated event tree number. Event tree title, description and related information are provided in following columns of Table 5.

Event trees were developed only for those release scenarios identified in the HAZOP for which Phast predicted that the hazard zone will travel offsite. Otherwise, in the "Further Analysis" column of the HAZOP Worksheets it is noted that the released material would not travel offsite. Appendix H provides all the event trees that were developed for this study.

An event tree starts with an initiating event and continues with various additional events that can have multiple outcomes. The chains of events or sequences of events are identified by considering the possible outcomes of events that follow the initiating event. The combinations of the events in an event tree represent a sequence of events with their own characteristic conditions and probability of occurrence. Figure 4 shows a simple event tree with only two branches. In this event tree, after a relief valve lift (the initiating event) the possibility of immediate and delayed ignition is examined because ignition time affects the hazard zone associated with this initiating event. The upper branch represents delayed ignition and the lower branch represents immediate ignition.

Table 5 – Release Types used for Event Tree Analysis

Event Tree	Title	Description	Description of Results
1	Gaseous Natural Gas Release with no Flash Fire	Release of gaseous natural gas to atmosphere through a relief valve vent due to pressure increase in the system or relief valve spring breaking. Phast dispersion model predicts that no flash fire offsite is possible.	Phast predicts that the release will not result in a flash fire offsite as the released material will rise above all potential ignition sources. If immediate ignition occurs at the release point, thermal radiation

Table 5 – Release Types used for Event Tree Analysis

Event Tree	Title	Description	Description of Results
			offsite due to jet fire is a possibility.
2	Liquid Natural Gas Release in Building	Release of liquid natural gas within the Storage Vault building due to mechanical failure of a pipe, flange, or tank (liquid side).	Phast predicts that a vapor cloud explosion is not possible. Flash fire offsite, and thermal radiation offsite due to a jet fire or pool fire are possible.
3	Liquid Natural Gas Release Outdoors	Release of liquid natural gas outside of the Storage Vault resulting in a liquid natural gas pool.	Phast predicts that flash fire offsite, and thermal radiation offsite due to a jet fire or pool fire are possible.
4	Liquid Natural Gas Release Outdoors Due to Tanker Hose Mechanical Failure	Release of liquid natural gas outside of the Storage Vault due to Tanker hose failure.	Phast predicts that flash fire offsite, and thermal radiation offsite due to a jet fire or pool fire are possible.
5	Fire Near the Buffer Tanks	A fire near the Buffer Tanks due causes other than natural gas leak resulting in increased pressure within the Buffer Tanks.	Phast predicts that flash fire offsite, and thermal radiation offsite due to a jet fire are possible.
6	Large CNG Release	Release of large quantity of CNG due to CNG piping failure, Vaporizer tube failure (vapor side), CNG Dispensing Station hose failure, or Fueling Station PSV lift.	Phast predicts that flash fire offsite and thermal radiation offsite due to a jet fire are possible.

A probability is associated with each branch point in an event tree. Once all possible outcomes of the events are examined and their associated probabilities are estimated, the probabilities of the chains of events can be determined.

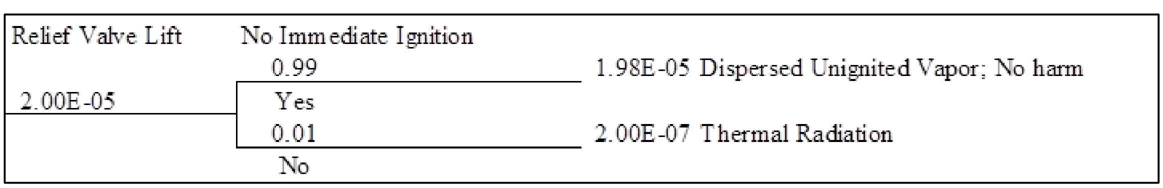


Figure 4 – Example of Event Tree 1

The probability of each sequence in an event tree is obtained from multiplying the initiating event frequency with the probabilities of the branch points of the sequence. In Figure 4, the initiating event probability ($2.5x10^{-5}$ per year or once in 4,000 year) is multiplied with the probability of immediate ignition (0.01) to obtain the event sequence probability ($2.5x10^{-7}$ per year or once per 400,000 years).

9.2 Event Probabilities

Probabilities of occurrence of the events considered in this study are estimated based on industry sources. Several reports provide failure rates for equipment and human error probabilities (see [Haag, 1999], [HSE, 2012], [PHMSA, 2015] and [CCPS, 2014]). From these sources the probability of occurrence of each initiating event (e.g., pipe break and hose rupture) and probability of failure of mitigative features (e.g., failure of an automatic shutoff system) are estimated. The estimated probability values, their bases and associated references are provided in Appendix H.

9.3 Hazard Distance vs Probability

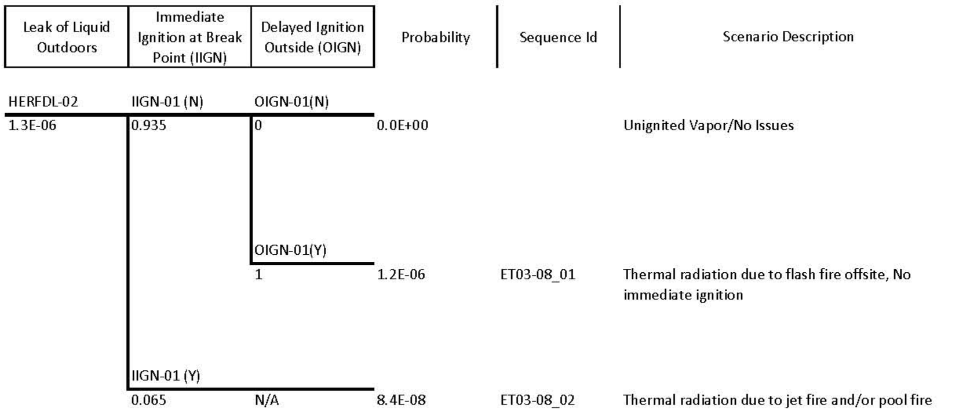
An event tree and one or more release categories are associated with each scenario in the HAZOP worksheets that may lead to offsite effects. For the events identified through each event tree, at least one Phast computation is conducted to establish the various hazard zones associated with the scenario. Figure 5 is an example case taken from Appendix H where the analysis associated with a release category is shown. The type of hazardous event (i.e., flash fire, jet fire, etc.) is specified for each event sequence. Phast results are summarized below for the three postulated weather conditions. For example, the hazard zone of a flash fire associated with 1.5 m/s wind speed and F stability weather condition can extend 885 feet. Thermal radiation down to 2kw/m2 for the same scenario may extend 308 feet and jet fire for the same thermal radiation level to 257 feet. These events can occur in all directions depending on the wind direction. Therefore, the orientation is noted as “All” for all cases. The shortest distance between the location of the release and the nearest site boundary is 20 feet for all cases. Therefore, the hazard zone for each case is 20 feet less as noted in the “Footprint Offsite” numbers.

The frequencies of the events are evaluated next. The frequencies are presented in a three column set (see bottom part of Figure 5): flash fire, 2 kW/m^2 impact and 10 kW/m^2 impact. The first two represent potential for injury to the person exposed to those conditions and last column (i.e., 10 kW/m^2) is assumed to represent conditions that may cause severe injury and even fatality if an exposed person is unable to self-evacuate. The three frequencies presented in each column are based on the fraction of the time that the weather is in specified category (see Appendix F for the bases of the fractions used). Note that the sum of the frequencies in each column is equal to the frequency of corresponding event sequence. The frequencies of the second and third columns are the same because the same event will lead to 2 and 10 kW/m^2 hazard zones, but at different downwind distances. The hazard distance of these events are taken to be the maximum estimated by Phast for each event sequence.

ET03-08

Release Category: HP Liquid Spill 4

Note: Event: 1" Pipe break outside near the Vaporizers. The release occurs downstream of the High Pressure Pumps. It is assumed that this event is represented by a 1" diameter opening at ground level and continues until the Storage Tank empties.



	Flash Fire (1/2 LFL)	Pool Fire (2 KW/m^2)	Jet Fire (2 KW/m^2)	Pool Fire (10 KW/m^2)	Jet Fire (10 KW/m^2)
1.5/F	885	308	257	154	194
Average	467	324	239	154	170
Santa Ana	443	251	220	146	150
Orientation					
1.5/F	All	All	All	All	All
Average	All	All	All	All	All
Santa Ana	All	All	All	All	All
Distance to Fence Line					
1.5/F	20	20	20	20	20
Average	20	20	20	20	20
Santa Ana	20	20	20	20	20
Footprint Offsite					
1.5/F	865	288	237	134	174
Average	447	304	219	134	150
Santa Ana	423	231	200	126	130
Offsite Effect Frequency					
1.5/F	4.7E-07	3.3E-08			3.3E-08
Average	6.8E-07	4.7E-08			4.7E-08
Santa Ana	6.1E-08	4.2E-09			4.2E-09

Figure 5 – Example of Hazard Distance vs Probabilities

The event tree analyses provide hazard distances and their probabilities of occurrence for various scenarios. The scenarios are grouped into those that may cause an injury (i.e., flash fire and 2kW/m^2 exposure events) and may the potential to cause fatality (i.e., 10kW/m^2 exposure events). A hazard distance versus probability of occurrence matrix can be put together for these two cases by bringing together all scenarios. It is common practice to present the probabilities of exceedance, which represent the probability of occurrence of certain hazard distance or greater. For example, an event with a maximum impact 100 feet downwind will also have an impact at 20 feet downwind, and so the probability of exceedance at 20 feet will take into account the probabilities of all events with a maximum impact of 20 feet or greater. Appendix H presents the results of the hazard distance vs. probability calculations, which are based on the offsite footprint distances and probabilities presented in Table H7 of Appendix H. The probability values in Appendix H are obtained by adding probabilities that are computed using the event trees for all scenarios that lead to a hazard distance equal or greater than the specified distance. For example, the probability that a 10kW/m^2 hazard zone will exceed beyond 170 feet from the facility boundary is approximately once per 200,000 year (5x10^{-6} per year).

From the data presented in Appendix H it can be concluded that the overall probability of experiencing an injurious event outside the facility boundaries is approximately once per 4,500 years and the probability of an event with the potential for a fatality offsite is approximately once per 65,000 years. It is important to understand that these probability values represent rare events that may never happen in the life of OmniTrans facility. One method to interpret these values is to consider a large number of similar facilities. For example, 2x10^{-4} per year (once in 5,000 years) can be interpreted as that there is a high likelihood that the event may occur once within one year if 5,000 similar facilities exist.

Additionally, from the data in Appendix H, the following can be stated:

- The hazard zone of 95% of events that may cause injury would not exceed 890 feet from facility boundary.
- The hazard zone of 95% of events that could be fatal would not exceed 180 feet from facility boundary.

10.0 UNCERTAINTIES

Uncertainty is inherent to risk analysis. As it can be seen in the definition of risk (see Section 4), one of the three parts that characterize risk deals with the likelihood of what can wrong. These uncertainties are represented by the event probabilities discussed in the preceding sections. Point values are used to express these probabilities. For example, in Appendix H the probability of experiencing a 170 feet or greater hazard zone is 5 x 10^{-6} per year, a single value.

There are uncertainties inherent in all engineering computations. These uncertainties arise from imperfect models of the events and imperfect statistical information. The following notes address some of the sources of uncertainties that are deemed to be important to this study.

- Single values are used for the input parameters for Phast runs. For example, the break size is specified as a 3” diameter opening on a hose 15 feet from the storage tank and pressure behind that point as 80 psig. These single values represent a range of possible parameter values.
- The formulae that form the bases of Phast computations model very complex physical phenomena in an idealized fashion. Much effort has been expended by experts to make these computational methods as real as practically possible. But there are still many uncertainties in these models that cannot be easily eliminated.

- Two ignition possibilities are considered in this study – immediate and delayed ignition. The delayed ignition is assumed to occur at the time when the vapor cloud is at its largest extent downwind. In an actual event, ignition may occur at any time after a release or not at all. This two-point model used in this study is a crude and conservative depiction of what may occur in an actual event. It is deemed that this practice is one of the significant sources of uncertainty in this study and the results presented are larger than what they may have been if the ignition time was modeled as a continuum between the point of release and largest cloud extent.
- Probability values employed for estimating scenario occurrence probabilities include uncertainties inherent in all statistical analyses. The values are taken from industry sources that are based on general industry settings that cover a wide range of design and application possibilities. These sources generally tend to over-estimate the probability values due to the nature of risk analysis practices, where the tendency is to over-estimate the risk to support a risk-averse approach. In some cases the uncertainties in the probability values can be significant. However, in the opinion of the analysts of this study, the probability values used are generally over-estimated.

11.0 CONCLUSIONS AND RECOMMENDATIONS

A study is conducted of the LNG storage and handling systems of OmniTrans public transit bus refueling station in the City of San Bernardino. The objectives of the study included:

- Ensure compliance with safety and regulatory requirements.
- Review of seismic aspects of the systems
- An assessment of the probability of an explosive atmosphere
- Identification of potential ignition sources
- A quantitative analysis of accident scenarios that includes small releases
- The probability and consequences of the explosion
- Study whether a hazardous or non-hazardous area exists at the fueling site.

The codes and standards that apply to LNG fueling stations are reviewed. A large number of standards were in effects when the original LNG storage, pumping and vaporization systems were designed and constructed. Since then, they have been consolidated into NFPA 52, which addresses LNG storage and fueling systems. In this study, the systems are reviewed against the current requirements and it is concluded that in general terms the systems comply with NFPA 52 requirements. There are only a few hardware related differences between the design and current NPFA 52 requirements. The balance of the differences relate to administrative issues that are partly met by current practices.

The seismic ruggedness of the systems is also reviewed in this study. The standard that was used at the time of design is compared with current standards and it is concluded that the margin of safety used in the original design well covers the new requirements. Additionally, a system walk-down was conducted. From that direct observation of the physical systems a few recommendations are proposed to improve seismic safety of the storage and handling systems.

To address the last five bulleted items of the objective listed above, a risk analysis is conducted where a set of potential release scenarios are identified. The hazard zone of each scenario is estimated, and for those that can extend outside the facility boundary, probability of occurrence is estimated. Scenarios are identified by using HAZOP methodology (a method commonly used in the chemicals processing and petroleum refining industries) and later refined through the application of event trees where various potential conditions that can influence the hazard zone are included in the model. With this methodology, a wide range of scenarios are identified that includes small and large releases depending on the specific conditions of the event. For example, a flange failure is expected to lead to a small release, while hose break when unloading a truck is expected to lead to a large release.

Several computer programs were examined for estimating the shape and dimensions of potential hazard zones. Phast [DNV, 2015] was selected for this study since it offers the most sophisticated features that model release of LNG. Hazard zone computations take into account release conditions (e.g., liquid release and evaporation), formation of a gas cloud, and ignition leading to jet fire, pool fire and flash fire. The possibility of BLEVE and vapor cloud explosion are examined, and it is concluded that neither pose a credible threat at this facility. However, several scenarios are concluded to have an impact outside the facility boundary through thermal radiation.

From these analyses it is concluded that an explosive atmosphere is only possible in confined spaces. At this facility, the only confined space in which LNG may be released is the Storage Vault, which is protected through explosion proof electrical equipment (i.e., all ignition sources are fully isolated within the Vault) and a manually activated foam fire protection system. As noted above, explosion is not credible in the open areas outside the Vault.

Specific ignition sources are not examined explicitly in this study. It is assumed that ignition is possible everywhere. Two ignition times are considered: *immediate* (i.e., ignition occurs upon release of LNG) and *delayed* (i.e., ignition occurs when the gas cloud is at is maximum extent within the flammable range.) This leads to conservative results because it does not take into account the possibility of ignition before maximum extent is reached, which will predict a smaller hazard zone. It also does not take into account the possibility of no ignition before the gas dissipates below its flammable concentration.

Scenario probabilities are also estimated in this study using failure probabilities and human error rates provided in various industry sources. The hazard zones are divided into two categories: (1) potential for injury and (2) severe injury with the possibility of fatality if the exposed person is unable to self-evacuate. In the first category, flash fire scenarios and hazard zones of $2kW/m^2$ thermal radiation are assumed to have the potential to cause an injury. In the second category, $10kW/m^2$ thermal radiation is assumed to cause a condition where, if an exposed person does not get an opportunity to self-evacuate (e.g., falls and becomes incapacitated), a severe or even a fatal injury is possible. The total probabilities of the two hazard categories are concluded to be once per 3,500 years and once per 47,000 years, respectively. These probabilities demonstrate that offsite impact of LNG operation at OmniTrans facility is a rare event, which is also corroborated by the industry experience. From a review of industry events since mid-1940s, none of the reported LNG release events has adversely affected public safety. These probabilities are deemed to be conservative given the uncertainties in the hazard zone modeling and that event probability sources tend to report probability values conservatively.

From a study of scenario probabilities and hazard zones it is concluded that 95% of potential injury scenarios may extend up to 880 feet from the facility boundary and 95% scenarios with the potential for severe injury may extend up to 175 feet from the facility boundary.

As a final conclusion, it can be stated that there is no regulatory requirement for OmniTrans to modify any of its current practices, and that this study did not discover any significant safety deficiencies. However, based on direct inspection of the physical systems, observations of LNG receiving operations, review of current OmniTrans practices and review of current codes and standards, a list of recommendations are put together as potential improvement suggestions for the consideration of OmniTrans management. The recommendations are listed in Table 6 bellow.

Table 6 – Suggested Improvements

No.	Recommendations
R01	Consider posting signage along walls where CNG piping is fastened to prohibit placement of items and vehicles within the vicinity of the wall.
R02	Consider additional security measures by installing an alarm on the LNG building doors and fill station access hatch.
R03	Consider implementing a comprehensive housekeeping practice that prohibits placement of items and vehicles within 10 feet of LNG and CNG tanks, equipment, and piping.
R04	Consider adding the rain caps on the vertical vent pipes of the relief valves at the CNG Buffer Tanks to a maintenance program to ensure they are properly maintained and remain closed under normal conditions.
R05	Consider posting warning signs, with lettering large enough to be visible and legible from each point of transfer, at the dispensing points with the following words: A. STOP MOTOR. B. NO SMOKING. C. FLAMMABLE GAS. D. NATURAL GAS VEHICLE FUEL CYLINDERS SHALL BE INSPECTED AT INTERVALS NOT EXCEEDING 3 YEARS TO ENSURE SAFE OPERATION OF THE VEHICLE E. NATURAL GAS FUEL CYLINDERS PAST THEIR END-OF-LIFE DATE SHALL NOT BE REFUELED AND SHALL BE REMOVED FROM SERVICE.
R06	Install warning signs with the following words at the Storage Vault and at the Buffer Tanks: "NO SMOKING, FLAMMABLE GAS"
R07	Consider posting the service pressure at each dispenser so that it will be in view of the operator.
R08	Consider installing a barrier at the LNG piping between the Storage Vault and the LNG Vaporizers so that in the case of an integrity failure of the LNG containing piping, saturated LNG is deflected upward.
R09	Consider implementing a comprehensive housekeeping practice that prohibits placement of rubbish, debris, and other materials that present a fire hazard within 25 feet of the Storage Vault and the LNG Vaporizers.
R10	Consider the addition of LNG storage tank operating status indicators including tank level indication in the unloading area where the indicators can be directly observed by the LNG truck driver.
R11	Consider providing fire protection equipment at the LNG offloading site.
R12	Due to lack of the capability for positive isolation, consider including in the Maintenance Program a requirement to shut down both vaporizers when the systems must be opened for maintenance.
R13	Consider posting the following information on the LNG storage tanks: 1. Nominal liquid capacity 2. Maximum permitted liquid density 3. Maximum filling level

Table 6 – Suggested Improvements (continued)

R14	Consider maintaining documentation of the regulatory agency requirement to install the LNG tanks in a building along with the design features of the building necessary to safely accommodate the tanks inside of a building.
R15	Consider developing a formal Management of Change Program that ensures all future changes to the LNG storage and handling systems comply with NFPA 52 requirements.
R16	Consider including within the facility maintenance program a validation of the refueling station and associated storage equipment not less than every 4 years. The validation should include the following elements: 1. Process safety analysis and hazard and operability studies (HAZOPS) 2. Mitigating fire protection measures such as suppression systems 3. Systems or vaults for the containers 4. Fire and gas detection systems designed to interface with an emergency shutdown device (ESD) 5. Ventilation and other facility features 6. Spill containment adequacy administered by qualified engineer(s) with proven expertise in these fields
R17	Consider including security elements in a Security Program and insure they are in compliance with Section 12.5 of NFPA 52.
R18	Consider including maintenance practices within a Maintenance Program and insure they are in compliance with NFPA 52.
R19	Develop a formal training program for all personnel that work with LNG storage and handling systems to comply with Section 12.4 of NFPA 52.
R20	Develop a formal procedure to address leaks in the LNG storage and handling systems.
R21	Consider developing a formal ignition source control program for the areas within 10feet of the bus fueling stations.
R22	Consider developing a formal ignition source control program for the LNG Storage Vault, vaporizer area and Buffer Tank Area within 10 feet of system equipment and piping.
R23	Consider creating an exclusionary area near the delivery truck to minimize the presence of an ignition source during LNG transfer.
R24	The written procedures that address LNG storage and handling systems and bus fueling related operations shall explicitly address Personal Protective Equipment (PPE) requirements and usage.
R25	Consider developing a formal Fire Protection Program that addresses Section 10.13.7, 10.13.8 and 10.13.9 requirements of NFPA 52.
R26	Consider including emergency response issues in an Emergency Response Program and insure they are in compliance with NFPA 52.
R27	Ensure that bus fueling procedure is posted at the dispensing station.
R28	Ensure that the newly constructed bus fueling stations are equipped with methane detectors. Consider further evaluation of the installation of site methane detection systems as specified in 5.2.1.1.1
R29	Ensure that the pressure safety valves to be installed in the new refueling facility are vented to a safe point of discharge.

Table 6 – Suggested Improvements (continued)

R30	Ensure that there is at least one emergency manual shutdown device within a distance greater than 25 feet from the dispensing area.
R31	Consider adding a foam activation switch at the control panel where the security cameras are monitored.
R32	Consider installing a barrier on top of the LNG lines downstream of the Positive Displacement Pumps to prevent pipe damage due to impact.
R33	Develop a leak response plan in case of a leak detection alarm in the Storage Vault.
R34	Consider adding a call-out system to the leak detection system that calls out key personnel in case of a leak.
R35	Ensure that all inspection and maintenance records are provided by the maintenance contractor in a timely fashion.
R36	Consider instituting a periodic audit of the various programs associated with the LNG storage and handling systems to review maintenance records, LNG delivery vendor performance and training records,
R37	Consider developing written instructions for monitoring LNG delivery to specifically address the location of the sensors, periodic calibration of the sensor device, and specific duties and timing of the OmniTrans person monitoring the delivery.
R38	Consider reviewing emergency shutdown of the truck with the vendor for the possibility of OmniTrans personnel to activate in the event of an emergency.
R39	Consider creating an exclusionary zone no less than 25 feet from the delivery truck where no vehicles are allowed to enter.
R40	Increase the clearance between South access ladder landing and the nearest Storage Tank to minimize the potential for damage in case of an earthquake.
R41	Increase the flexibility of the two LNG pipes between North wall of the Storage Vault and Vaporizers to minimize the likelihood of pipe damage in case of an earthquake and independent movement of the North wall and Vaporizers.
R42	Increase the flexibility in the pipes between the Vaporizers and North property boundary wall to minimize the likelihood of pipe damage in case of an earthquake.
R43	Review the LNG pipe connection to the northerly site property line retaining and fence wall to verify that pipe connections to the wall meet seismic design conditions.
R44 R45	Review the anchorage and foundation of the Vaporizer to verify its seismic design basis Review the northerly site property line retaining wall and fence wall to verify its seismic design basis.

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LNG Operations Risk Assessment

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Presented at

OmniTrans

May 11, 2015

Project Scope

The objectives of this study can be summarized as:

- Review and assess compliance with safety and regulatory requirements.
- Review and assess seismic aspects of the LNG storage and handling systems
- Assess the probability of an explosive atmosphere
- Identify potential ignition sources
- A quantitative analysis of accident scenarios
- Whether a hazardous or non-hazardous area exists

Compliance with Safety and Regulatory Requirements

A compliance analysis was done against NFPA 52.

- NFPA 52 (2013) is the most recent code covering all aspects of a CLNG system.
- The physical systems were found, in general terms, compliant with the current requirements.
- Suggestions are provided to meet the administrative aspects of NFPA 52.

Seismic Review

A seismic review of the LNG storage and handling systems was conducted.

- The original design is based on 1997 UBC, seismic zone 4, which is stricter than current code requirements for OmniTrans Facility location.
- Three minor upgrades are proposed based on a field review of the as-built systems.

Release Analysis

- A detailed analysis of potential release scenarios was conducted.
- Some of the scenarios may have adverse offsite effects.
- Adverse effects include:
  - Flash fire
  - Pool fire
  - Jet fire
  - Vapor cloud explosion – not possible outdoors
  - BLEVE – very unlikely

Release Analysis – Adverse Effects

- Flash Fire
  - Unignited methane gas travels down wind and touches off on an ignition source before it is diluted below LFL
  - Gas cloud burns by flashing back to the source
  - Short duration exposure to flames
- Pool fire
  - Released LNG forms a pool and ignites
  - Flames of burning pool radiates heat onto the surrounding items
- Jet fire
  - LNG or CNG releases under pressure from a small opening
  - Released material ignites forming a jet fire
  - The fire radiates heat onto the surrounding items

Release Analysis – Hazard Footprint

- **Hazard zone depends on multitude of parameters:**
  - **Rate of release**
  - **LNG vs. CNG**
  - **Release orientation**
  - **Wind direction**
  - **Wind speed**
  - **Atmospheric stability**

Release Analysis – Offsite Impact

- There is one in 3,500 chance per year for an event that may cause an injury offsite and 95% of such scenarios extend less than 880 feet offsite.
- There is one in 47,000 chance per year for an event that may cause severe injury offsite and 95% of such scenarios extend less than 175 feet offsite.
- Such events have not been experienced in the LNG facilities similar to OmniTrans.

Industry Incidents

- There have been no incidents at the OmniTrans Facility.
- Twenty four major LNG-specific industry incidents were reviewed (since 1944), of which 12 are found relevant to OmniTrans operation.
- Of these 12 industry events, none caused fatality or injury outside the facility.

Conclusion

- Current design and operation are within accepted practices.
- Administrative changes may be warranted to enhance safety.
- There are scenarios, although unlikely, that may adversely affect the public outside the facility

OmniTrans
Connecting Our Community.

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ITEM # E3

DATE: May 11, 2015

TO: Committee Chair Sam Spagnolo and
Members of the Operations and Safety Committee

THROUGH: P. Scott Graham, CEO/General Manager

FROM: Donald Walker, Director of Finance

SUBJECT: **COMPRESSED NATURAL GAS (CNG) FUELING INFRASTRUCTURE FEASIBILITY STUDY**

FORM MOTION

Recommend the Board of Directors receive and file the final report on the CNG Fueling Infrastructure Feasibility Study; and

Recommend the Board of Directors approve the recommendation to proceed with developing the preliminary design, technical specifications and solicitation documents with our "On Call" Architect and Engineering firm STV.

BACKGROUND

Previously Omnitrans solicited and awarded a contract to Clean Energy (RFP-FIN14-269 CNG Fueling Infrastructure Feasibility Study) to evaluate the viability, cost(s) and benefits associated with implementing pipeline CNG fueling operations at its East Valley (EV), West Valley (WV), and "I" Street facilities. The feasibility study was performed to provide an alternative to Omnitrans' current fueling operations.

Omnitrans' current bus fueling operation requires delivery of liquefied natural gas (LNG), stored in two (2) 30,000 gallon tanks at EV, and one (1) 20,000 gallon tank at WV. The LNG is converted into CNG before fueling the buses. Converting LNG to CNG requires one and one-half (1.5) gallons to LNG to produce one (1) gallon of CNG. This process increases the cost to fuel our buses significantly. The current paratransit fleet located at I Street uses unleaded gasoline, but is transitioning to CNG.

RESULTS OF FEASIBILITY STUDY

First and foremost, the feasibility study concluded that there were no jurisdictional, operational, economical, or technical restrictions that would prevent Omnitrans from pursuing a pipeline CNG fueling infrastructure at its facilities. ***Note:*** *Omnitrans previously operated a CNG fueling facility at both EV and WV sites from 1996 – 2002.*

Second, based on current fuel consumption and LNG cost, the study estimated an annual savings in operational cost of $760,000 and $465,000 at EV and WV respectively, after implementation of a pipeline CNG fueling station. The estimated reduction in operational cost for the Paratransit fleet based at I Street increases from $137,000 to $659,000 once the fleet (44 vehicles) transitions from gasoline to CNG. Omnitrans can expect to realize a total cost reduction of $1.9M in fueling cost after implementation of a pipeline CNG fueling infrastructure at the three (3) facilities, and the transition of the paratransit fleet from unleaded to CNG.

Third, the estimated cost to install a pipeline CNG fueling station is approximately $2.3 million at the EV facility; approximately, $1.7 million at the WV facility; and approximately $1.6 million at the I Street facility. The total cost for installing the pipeline CNG fueling stations at the three (3) facilities is estimated at $5.6 million. This cost includes the utilization of some existing components from the LNG fueling infrastructure.

Finally, implementation of a pipeline fueling station at the three (3) facilities, particularly EV, will hopefully alleviate the nearby community's concerns regarding the LNG facility. The pipeline CNG fueling station will utilize pipeline gas from the Southern California Gas Company. The method of delivery is through the existing pipeline, thus eliminating the need for the storage tanks. Currently, Omnitrans pays over $300,000 annually on operational and maintenance (O&M) costs to ensure its fueling facilities complies with all existing regulatory requirements.

If recommended to move forward to the Board by the Committee, staff will work with STV, Inc., Omnitrans' on call Architect and Engineering firm to develop the preliminary design, technical specifications and solicitation documents and will present it to the Board of Directors for approval.

CONCLUSION

Investing in a pipeline CNG fueling infrastructure is a safe, economical, dependable, and cost effective means of fueling our fleet. A pipeline fueling strategy will eliminate the cost associated with liquefaction, LNG tanker deliveries, LNG storage tanks, and the regasification to CNG.

PSG: DW

OmniTrans

Request for Proposals
(RFP – FIN 14-269)

CNG Fueling Infrastructure
Feasibility Study
Final

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April 20, 2015

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TAB I Executive Summary

In response to OmniTrans Request for Proposal (RFP – FIN -14-269) CNG Fueling Infrastructure Feasibility Study, Clean Energy has evaluated the viability, cost(s) and benefits associated with implementing pipeline CNG fueling operation(s) at two (2) bus facilities and one (1) Paratransit facility. The following report is the final pipeline CNG evaluation of the OmniTrans bus and fueling operations. Subsequent to meetings with OmniTrans beginning on February 9, 2015, Clean Energy has modified the original findings of the draft report and incorporated the updates in this final version.

Clean Energy compared the current LCNG fueling data and operational expenses to the projected cost(s) and potential benefits of OmniTrans utilizing pipeline Compressed Natural Gas (CNG). The Clean Energy evaluation includes; legal review of potential jurisdictional restrictions, operational feasibility, economic impact, technical requirements, estimated timeline and location of the proposed pipeline CNG stations at each facility. Clean Energy also reviewed OmniTrans current LCNG equipment for synergies and found several areas where the same assets can be optimized with the new pipeline CNG stations.

OmniTrans currently uses Liquefied Compressed Natural Gas (LCNG) at both the East and West Valley operations fueling a fleet of approximately 181 buses. The cumulative savings for the fixed route fleet could be up to $13.5 million over the next ten (10) years. This number does not include the cost to design and build the stations but does include the cost to operate and maintain the CNG facilities.

OmniTrans services 15 cities covering a service area of approximately 480 square miles. This large area requires the OmniTrans fleet to burn double the industry average for fuel consumption per bus. The average transit bus burns 10,000 gallons of fuel per year; OmniTrans burns over 20,000 gallons. The average Paratransit bus burns 5,000 gallons per year and the OmniTrans paratransit fleet burns over 10,000 gallons per year per bus. These large numbers account for the dramatic fuel savings OmniTrans can achieve by utilizing pipeline CNG.

To properly evaluate the cost of three (3) pipeline CNG stations, Clean Energy estimated the cost of capital for OmniTrans based on a standard lease rate of seven (7) years with 4.25% interest. This allows OmniTrans an opportunity to evaluate one option for a pipeline CNG program without the cost of upfront capital.

TAB II Site Summaries

East Valley Bus Facility

The East Valley Facility operates a fleet of 118 CNG buses with 90 active and approximately 28 in reserve or maintenance. The fueling window is from 6:30pm to 3:30am. The dwell time for each bus to fuel and perform other functions such as cleaning and fare box service is approximately 12 minutes. Saturday fueling includes an estimated 2/3 of the fleet or approximately 60 buses and Sunday fueling includes an estimated 1/3 of the fleet or approximately 30 buses.

The East Valley facility has two (2) 30,000 gallon LNG tanks providing onsite storage for approximately eleven (11) days of fuel usage. The facility converts odorless LNG into LCNG and dispenses approximately 5,400 gallons per day for the 90 active buses. OmniTrans is operating from a temporary fuel island with two (2) lanes and is under construction for a new permanent fuel island with three (3) lanes capable of fueling articulated buses.

The average fuel consumed per bus is approximately 45.9 gallons per day. This is an average for the entire fleet and the actual fuel consumed per bus varies by day, route and bus type. The OmniTrans East Valley fleet consumes approximately 162,494 gallons of fuel per month or 1.7 million gallons per year. The East Valley OmniTrans bus fleet consumes an average of 21,665 gallons per bus per year which is well above the industry averages (10,000 gallons per year) for fuel consumed per bus per year.

Based on the fueling requirements outlined above, Clean Energy has calculated the capacity and equipment specifications for a pipeline CNG station at this location. The equipment specifications can be found in the Technical Feasibility section of the report; TAB VI.

West Valley Bus Facility: 4748 Arrow Highway, Montclair

The West Valley Facility operates a fleet of 63 CNG buses with 54 active and approximately 9 in reserve or maintenance. The 54 active buses currently use two (2) fueling lanes and the dwell time for each bus to fuel and perform other functions such as cleaning and fare box services is 12 minutes per bus. The fueling window is from 5:30pm to 1:00am. Saturday fueling includes an estimated 2/3 of the fleet or 36 buses. Sunday fueling includes an estimate 1/3 of the fleet or 18 buses.

The West Valley facility has two (2) 30,000 gallon LNG tanks providing onsite storage for approximately twenty (20) days. This facility, like East Valley also converts odorless LNG into LCNG and dispenses approximately 2,991 gallons per day for the 54 active buses. The average fuel consumed per bus is approximately 47.5 gallons per day. The West Valley fleet consumes an average of 19,944 gallons of fuel per year per bus and over 1.0 million gallons total.

Based on the fueling requirements outlined above, Clean Energy has calculated the capacity and equipment specifications for a pipeline CNG station at this location. The equipment specifications can be found in the Technical Feasibility section of the report; TAB VI.

I Street Paratransit Facility

The I Street Paratransit Facility operates a total of 62 Paratransit (gasoline) buses with 44 active and approximately 18 in reserve or maintenance. The 44 active buses currently fuel early in the morning prior to leaving on routes with an estimated fuel time of 6 to 7 minutes per bus. The average bus consumes approximately 20.2 gallons of fuel per day per bus and 37,508 gallons per month. The I Street fleet consumes 450,000 gallons of fuel per year and a staggering 10,229 gallons per year per bus. This is well above the industry averages (5,000 gallons) for a Paratransit bus.

Based on the fueling requirements outlined above, Clean Energy has calculated the capacity and equipment specifications for a pipeline CNG station at this location. The equipment specifications can be found in the Technical Feasibility section of the report; TAB VI.

TAB III Legal Feasibility

Scope of Work: Determine whether the fueling station conflicts with legal requirements, e.g. jurisdictional restrictions.

Clean Energy consulted with our internal legal and permitting departments regarding the installation of a pipeline CNG station at the OmniTrans fueling facilities. Clean Energy did not find any specific legal impediments preventing OmniTrans from moving forward with a pipeline CNG station.

OmniTrans management has requested the pipeline CNG station under consideration must meet the highest safety standards in the industry. Specific construction considerations, project development requirements and permitting issues will need to be addressed for each site considering the close proximity to residential housing and schools. Clean Energy recommends the following language for sound attenuation for the new pipeline CNG station.

Any and all design and implementation must comply with all applicable codes and standards for safety, fire, health and local requirements such as The National Fire Protection Agency Code 52 (NFPA52). This code covers the design, installation, operation, and maintenance of CNG and LNG fuel systems on all vehicle types--plus their respective compression, storage, and dispensing systems. This Code applies to all facilities with LNG storage in containers of 70,000 gallons or less.

> The compressor skid including but not limited to, the dryer, inter-stage heat exchangers, pulsation vessels, blowdown vessels, liquid separation tanks, gauges and related piping and tubing shall be housed in a weatherproof and acoustically lined metal enclosure. The noise level immediately outside any point of the CNG station area (15 foot radius) shall be < = 75 dbA.

TAB IV Operational Feasibility

Scope of Work: Determine the impact of the fueling station on operational cost.

OmniTrans can reduce operating costs by utilizing pipeline CNG. Cumulative savings for each facility is described below and does not include the cost of capital. Clean Energy evaluated the cost OmniTrans is paying for delivered LNG per gallon and compared the data to the price OmniTrans would pay for pipeline CNG.

Clean Energy also compared the pipeline CNG cost for the I Street Paratransit fleet which uses gasoline. To make these comparisons equal Clean Energy converted the fuel prices to Gasoline Gallon Equivalents (GGE's). The table below illustrates the energy content in each fuel Clean Energy used to calculate the dollar values.

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CONVERSION TABLE					
Measurement	BTU Content	mmbtu content	Therms	Multiplier to = DGE	Multiplier to = GGE
D.G.E.	139,000	0.139	1.39	n/a	1.112
G.G.E.	125,000	0.125	1.25	0.899 or /1.112	n/a
LNG Gallon	82,000	0.082	0.82	1.7	1.5

The table below illustrates the current cost(s) for pipeline CNG, LCNG (OmniTrans current fuel) & Gasoline. The savings per gallon for pipeline CNG compared to LCNG is approximately $0.44 cents per GGE and approximately $1.12 when compared to gasoline. Please note the commodity cost for pipeline CNG is much lower than LCNG due to the lower energy content per LNG gallon. However they both start with a base rate of $4.06 per MMBTU. Please note that these prices are for fuel only and do not included the capital cost for stations.

Pipeline CNG		L/CNG		Gasoline	
Commodity Cost	$ 0.5100	Commodity Cost	$ 1.2800	Commodity Cost	$ 2.2500
Electricity	$ 0.2000	Electricity	$ 0.1000	Electricity	$ -
O&M	$ 0.2500	O&M	$ 0.1000	O&M	$ -
Taxes	$ 0.0100	Taxes	$ 0.0100	Taxes	$ -
SoCal Gas Transportation Rate	$ 0.1624	CA Tax	$ 0.0825		
Capital Cost (unknown)	$ -	Capital Costs (zero)	$ -	Capital Cost (unknown)	$ -
Total Cost Pipeline CNG	$ 1.1324	Total Cost L/CNG	$ 1.5725	Total Cost Gasoline	$ 2.2500

NOTES:
Pipeline CNG = So Cal Gas NGV1 rate Q4 2014 $4.06 / 8 = $0.51 cents per GGE
L/CNG = So Cal Gas rate $4.06 / 12.1 + $0.5168 = $0.8523 x 1.5 (convert to GGE) = $1.28 cost per L/CNG gallon converted to GGE
Gasoline - prices are at record lows. Industry experts expect prices to remain low until Q3 of 2015 when over supply is corrected.

East Valley Operations

The proposed pipeline CNG station can reduce operational costs for the East Valley facility by approximately $760,000 per year. This costing model does not take into account capital costs. The cost of capital will need to be determined by OmniTrans. However for a complete cost model Clean Energy developed a lease option which can be found in Tab X. The cost of the East Valley pipeline CNG station is approximately $2,294,906. Details of the station cost can be found in Tab VI.

East Valley		
Annual Fuel Volume		1,728,000
Pipeline CNG Fuel Savings (per gallon)	$	0.44
Annual Operational Budget Savings	$	760,320.00

West Valley Operations

The proposed pipeline CNG station can reduce operational costs for the West Valley facility by approximately $464,000 per year. This costing model does not take into account capital costs. The cost of capital will need to be determined by OmniTrans. However for a complete cost model Clean Energy developed a lease option which can be found in Tab X. The cost of the West Valley pipeline CNG station is approximately $1,708,362. Details of the station cost can be found in Tab VI.

West Valley		
Annual Fuel Volume		1,056,000
Pipeline CNG Fuel Savings (per gallon)	$	0.44
Annual Operational Budget Savings	$	464,640.00

Paratransit Operations

The proposed pipeline CNG station can reduce operational costs for the Paratransit fleet based at I Street, when the fleet if fully converted. This is a conservative estimate considering the price of gasoline is at a record low and as the United States cuts domestic production many industry experts expect the price of crude oil (gasoline) to dramatically climb toward the end of 2015. The savings for year one (1) will be approximately $137,000 and growing depending on the number of CNG paratransit buses and the increasing cost of gasoline after 10 years. A detailed cost and benefit analysis can be found in Tab VI.

This costing model below does not take into account capital costs. The cost of capital will need to be determined by OmniTrans. However for a complete cost model Clean Energy developed a lease option which can be found in Tab X. The cost of the I Street Paratransit facility pipeline CNG station is approximately $1,564,010. Details of the station cost can be found in Tab VI.

Paratransit Operations		
Annual Fuel Volume		122,748
Pipeline CNG Fuel Savings (per gallon)	$	1.12
Annual Operational Budget Savings	$	137,477.76

TAB V Economic Feasibility

Scope of Work: Determine the positive economic benefits to the organization that the proposed fueling station will provide, and include quantification and identification of all the benefits expected. This will include a cost/benefit analysis.

East Valley Operations

In order to properly evaluate the costs and benefits of installing a pipeline CNG station, Clean Energy has estimated the cost of capital for OmniTrans based on standard lease rate; seven (7) years with 4.25% interest. The installation of a pipeline CNG station for the East Valley facility will cost an estimated $2.3 million or approximately $0.20 cents per gallon. This cost is not included in the chart below.

In the table below Clean Energy uses the Henry Hub spot price as the index for the cost of Natural Gas per MMBTU. This index is commonly used in the natural gas industry for forecasting future commodity prices. Including capital costs, OmniTrans can realize potential savings in excess of $500,000 per year in the first year and increasing to more than $750,000 per year with savings more than $7,000,000 over 10 years.

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Omnitrans ROI Forecast / East Valley Fleet										
Prices	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Natural Gas Prices										
Henry Hub Spot Price / highest baseline	$4.06	$4.16	$4.26	$4.36	$4.46	$4.57	$4.68	$4.79	$4.91	$5.03
Gasoline Gallon Equivalent Price	$0.51	$0.52	$0.53	$0.54	$0.56	$0.57	$0.59	$0.60	$0.61	$0.63
Capital Recovery is not included										
Station Maintenance 100% Parts / Labor	$0.250	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500
Electricity & Communications	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000
State Taxes (if applicable)	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100
SoCal Gas Transportation rate	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624
Total Price per GGE	$1.1299	$1.1421	$1.1546	$1.1673	$1.1804	$1.1938	$1.2075	$1.2216	$1.2359	$1.2507
LCNG cost/GGE (includes $.0825 tas)	$1.5725	$1.5825	$1.5925	$1.6025	$1.6225	$1.6325	$1.6525	$1.6625	$1.6725	$1.6925
Cost Savings per Gallon (CNG vs. LCNG)	**$0.4426**	**$0.4404**	**$0.4379**	**$0.4352**	**$0.4421**	**$0.4387**	**$0.4450**	**$0.4409**	**$0.4366**	**$0.4418**
Total CNG Buses in Fleet	90	90	90	90	90	90	90	90	90	90
Total Annual Fuel Savings	**$501,717**	**$761,046**	**$756,774**	**$751,984**	**$763,945**	**$758,084**	**$768,947**	**$761,961**	**$754,393**	**$763,509**
Total Cumulative Fuel Savings	**$501,717**	**$1,262,763**	**$2,019,537**	**$2,771,521**	**$3,535,466**	**$4,293,549**	**$5,062,496**	**$5,824,457**	**$6,578,851**	**$7,342,359**
Annual LNG consumption per bus	**19,200**									

NOTES:
90 Active Bus Fleet
Fuel Savings are Cumulative

West Valley Operations

The cost to install a pipeline CNG station at the West Valley facility will be an estimated $1.7 million or $0.30 cents per GGE. This cost is not included in the chart below. Savings of approximately $467,000 in the first year and up to more than $600,000 per year after 10 years for cumulative savings of more than $4.8 million over 10 years.

Omnitrans ROI Forecast / West Valley Fleet										
Prices	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Natural Gas Prices										
Henry Hub Spot Price / highest baseline	$4.06	$4.16	$4.26	$4.36	$4.46	$4.57	$4.68	$4.79	$4.91	$5.03
Gasoline Gallon Equivalent Price	$0.51	$0.52	$0.53	$0.54	$0.56	$0.57	$0.59	$0.60	$0.61	$0.63
Capital Recovery is not included										
Station Maintenance 100% Parts / Labor	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500
Electricity & Communications	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000
State Taxes (if applicable)	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100
SoCal Gas Transportation Rate	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624
Total Price per GGE	$1.1299	$1.1421	$1.1546	$1.1673	$1.1804	$1.1938	$1.2075	$1.2216	$1.2359	$1.2507
L/CNG cost	$1.5725	$1.5825	$1.5925	$1.6025	$1.6225	$1.6325	$1.6525	$1.6625	$1.6725	$1.6925
Cost Savings per Gallon (CNG vs. Gas)	**$0.4426**	**$0.4404**	**$0.4379**	**$0.4352**	**$0.4421**	**$0.4387**	**$0.4450**	**$0.4409**	**$0.4366**	**$0.4418**
Total CNG Buses in Fleet	63	63	63	63	63	63	63	63	63	63
Total Annual Fuel Savings	**$467,386**	**$465,084**	**$462,473**	**$459,546**	**$466,855**	**$463,273**	**$469,912**	**$465,643**	**$461,018**	**$466,589**
Total Cumulative Fuel Savings	**$467,386**	**$932,469**	**$1,394,942**	**$1,854,488**	**$2,321,343**	**$2,784,616**	**$3,254,528**	**$3,720,171**	**$4,181,189**	**$4,647,778**
Annual Fuel Consumption (per bus)	**16,762**									

NOTES:
63 Active Bus Fleet
Fuel Savings are Cumulative

Paratransit Operations

The cost to install a pipeline CNG station at the I Street Paratransit facility will be an estimated $1.5 million or $0.65 cents per GGE. The capital cost is not included in the chart below. The operational savings increase every year as OmniTrans adds more CNG Paratransit buses to the fleet. Savings in year one are estimated at $137,000 and increases annually as paratransit buses are added and depending on the price of gasoline estimated below, savings could increase to more than $800,000 per year once the entire fleet is CNG provided the price of gasoline increases as indicated in the chart over the next 10 years and up to more than $6 million total.

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Omnitrans ROI Forecast / Paratransit Fleet

Prices	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Natural Gas Prices										
Henry Hub Spot Price / highest baseline	$4.06	$4.16	$4.26	$4.36	$4.46	$4.57	$4.68	$4.79	$4.91	$5.03
Gasoline Gallon Equivalent Price	$0.51	$0.52	$0.53	$0.54	$0.56	$0.57	$0.59	$0.60	$0.61	$0.63
Capital Recovery is not included										
Station Maintenance 100% Parts / Labor	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
Electricity & Communications	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
State Taxes (if applicable)	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
SoCal Gas Transportation Rate	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16
Total Price per GGE	$1.13	$1.14	$1.15	$1.17	$1.18	$1.19	$1.21	$1.22	$1.24	$1.25
EIA Gasoline Price / lowest baseline	$2.25	$2.35	$2.45	$2.55	$2.65	$2.75	$2.85	$2.95	$3.05	$3.15
Cost Savings per Gallon (CNG vs. Gas)	**$1.12**	**$1.29**	**$1.38**	**$1.47**	**$1.55**	**$1.64**	**$1.72**	**$1.81**	**$1.90**	**$1.90**
Total CNG Buses in Fleet	12	24	36	44	44	44	44	44	44	44
Total Annual Fuel Savings	**$137,490**	**$316,793**	**$507,421**	**$659,441**	**$698,562**	**$737,542**	**$776,378**	**$815,065**	**$853,601**	**$854,850**
Total Cumulative Fuel Savings	**$137,490**	**$454,283**	**$961,704**	**$1,621,145**	**$2,319,707**	**$3,057,249**	**$3,833,626**	**$4,648,691**	**$5,502,292**	**$6,357,142**
Annual Fuel Consumption (per bus)	**10,229**									

NOTES:
110 Unit Paratransit Fleet
Fuel Savings are Cumulative

Economic Considerations

(a) OmniTrans has faced challenges from the surrounding neighborhood regarding the storage of LNG on East Valley property. Pipeline CNG will render the current storage tanks unnecessary and they can be removed from the site.

(b) Some of the current OmniTrans LCNG assets are more valuable in place. Removing the storage tanks without a clear buyer may diminish the value. Clean Energy recommends keeping some assets in place until a suitable buyer can be found who will remove the equipment as part of the sale requirements from OmniTrans. Please note that for purposes of this evaluation, Clean Energy valued the existing assets at $0.00. The LCNG assets do have market value and the sale of such assets could be used to offset the cost of installing a pipeline CNG station. The LCNG assets are needed until the new station is operational and therefore proceeds of sale were not considered in this evaluation.

(c) OmniTrans can source Renewable Natural Gas (RNG) derived from landfills and waste treatment facilities. RNG is the cleanest transportation fuel in the world and available to OmniTrans through a pipeline CNG program. RNG is typically more expensive than traditional pipeline natural gas because of the intense processes to capture, extract, and process and purify. It can be considerably less than gasoline or diesel. Clean Energy has a RNG program specifically for our customers and we would work directly with OmniTrans to provide specific pricing at the time of interest.

(d) Fuel Security – Pipeline CNG offers OmniTrans direct access to the pipeline without reliance on fuel deliveries and storage capacity.

(e) Fuel Security Consideration – Should there be a disruption in pipeline CNG OmniTrans would be out of fuel and would need an alternate fueling strategy. LNG offers OmniTrans with supply in the event of a pipeline disruption.

(f) Evaporation – LNG evaporates if not used. Pipeline CNG is always available and only invoiced when pulled into the CNG fueling system as metered by the gas utility.

(g) The CNG compression equipment selected for OmniTrans will have multiple Methane Detection Sensors (MDS) inside the skid enclosures. This ensures the system will automatically shut down in the event of a leak preventing unwanted odors.

(h) The raw commodity costs for LCNG and CNG are identical. The savings on pipeline CNG come into play when considering the liquefaction and delivery costs of LNG.

(i) Pipeline CNG is more expensive equipment to maintain compared to LCNG.

(j) LNG is cleaner burning compared to pipeline CNG. OmniTrans will experience higher maintenance frequencies changing High Pressure (HP) and Low Pressure (LP) filters on the buses. Pipeline CNG has Non Gaseous Liquids (NGL's) that can plug up filters. OmniTrans maintenance staff will have to monitor the HP and LP filters to determine exact inspection frequency when switching over to pipeline CNG.

TAB VI Technical Feasibility

Scope of Work: Determine the present technical resources of OmniTrans and the applicability to the expected needs of the fueling station. This requires an evaluation of the hardware and software and its compatibility with the requirements of a fueling station.

The equipment (hardware) and program (software) specification requirements for the proposed fueling stations are outlined in the tables below. Clean Energy evaluated the LCNG fueling assets at the East and West Valley operations and identified equipment that can be used in the new pipeline CNG station. Clean Energy incorporated the value engineering opportunities (savings) into the revised pricing formula.

Term	Definition
MSA	Meter Set Assembly (MSA) refers to the metering equipment installed by the utility connecting the outside gas line to OmniTrans property
SCFM	Standard Cubic Feet per Minute (SCFM) refers to the amount of fuel (gallons) measured in cubic feet per minute flowing through a meter.

Clean Energy contacted the Southern California Gas Company regarding the gas pressure available at all three sites. The "Preliminary Site Evaluations" from SoCal Gas are included as a separate attachment for each of the three facilities.

East Valley Operations

The SCFM calculated for this site is 2140 SCFM or 1070 gallons per hour. One bus fueling 45.9 gallons will take less than three minutes to fill and two buses (91.8 gallons) will fuel in less than six (6) minutes. The Table below details the specific equipment required to meet OmniTrans fuel demands.

East Valley Equipment Configuration:

OmniTrans East Valley	
General	$ 1,117,668
Site Work	
Concrete	
Metals	
Specialties	
Equipment	
Mechanical	
Electrical	
Switch gear 1600A with kirk key and surge protection	
Tie into existing Fleet Watch Fuel Management System	
Tie discharge lines from compressors into existing carbon steel from the LCNG system	
Provide a kirk key in with gear for a generator (generator not included)	
No additional paving is included - only for back-filling/trenching	
Mics. Fees	
Engineering and Permitting Costs	$ 168,018
Engineering and design and consulting	
Programming	
Site Survey	
Permitting - does not include actual cost of permits	
Equipment Scope	
2 x twin 250 hp IMW compressor packages	
Reuse existing priority panel	
1 x PSB dryer (21-6)	
Reuse existing storage vessels	
Reuse existing AGNI dispensers	
1 x fuel support panel	
4 x filters	
1 x defueling panel	
Total IMW equipment	$ 818,904
Total non-IMW equipment	$ 90,350
Freight (could vary)	$ 13,718
Project Admin/Overhead/Insurance/Start-up	$ 86,248
Total East Valley CNG Project Installation	$ 2,294,906

West Valley Operations

The SCFM calculated for this site is 1070 SCFM or 535 gallons per hour. One bus fueling will take less than six minutes to fill and two buses will fuel in approximately eleven minutes. The Table below details the specific equipment required to meet OmniTrans fuel demands.

West Valley Equipment Configuration:

OmniTrans West Valley		
General		$ 893,809
Site Work		
Concrete		
Metals		
Specialties		
Equipment		
Mechanical		
Electrical		
Switch Gear	1600A with kirk key and surge protection	
Tie into existing Fleet Watch Fuel Management System		
Tie discharge lines from compressors into existing carbon steel from the LCNG system		
Provide a kirk key in with gear for a generator (generator not included)		
No additional paving is included - only for back-filling/trenching		
Mics. Fees		
Engineering and Permitting Costs		$ 122,400
Engineering and Design		
Engineering Consultant		
Programming		
Site Survey		
Permitting - does not include actual cost of permits		
Total Engineering & Permitting		
Equipment Scope		
1 x twin 300 hp IMW compressor package		
1 x priority panel		
1 x PSB dryer (21-4)		
2 x single hose transit dispensers		
1 x fuel support panel		
Reuse existing storage vessels		
2 x filters		
1 x defueling panel		
Fuel Support Panel		
Total IMW Equipment		$ 432,710
Total Non-IMW Equipment		$ 188,769
Freight (could vary)		$ 7,963
Project Admin/Overhead/Insurance/Start-up		$ 62,711
Total East Valley CNG Project Installation		$ 1,708,362

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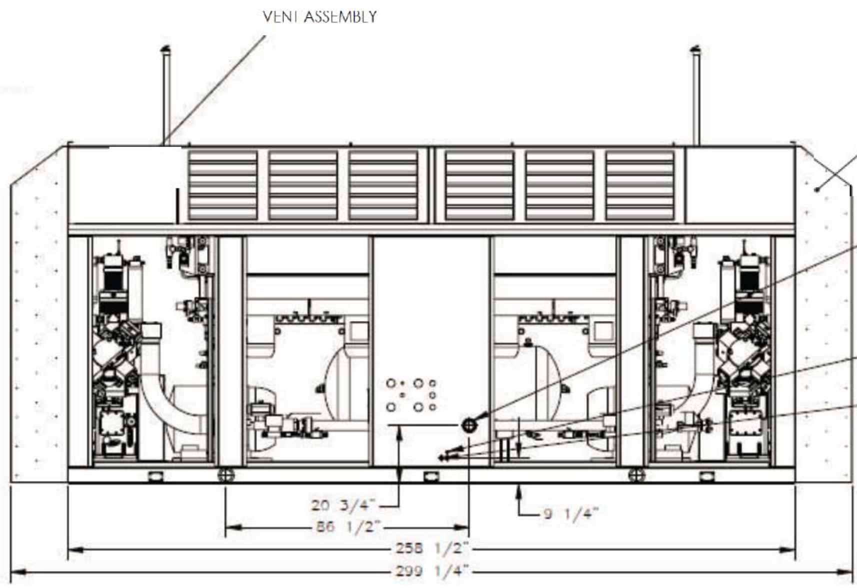
I Street Paratransit Operations

The SCFM calculated for this site is 526 SCFM or 263 gallons per hour. One bus will take less than five minutes to fuel. The Table below details the specific equipment required to meet OmniTrans fuel demands.

I Street Equipment Configuration:

OmniTrans I Street		
General	$	895,688
Site Work		
Concrete		
Metals		
Specialties		
Equipment		
Mechanical		
Electrical		
Switch Gear 1600A with kirk key and surge protection		
Tie into existing Fleet Watch Fuel Management System		
Tie discharge lines from compressors into existing carbon steel from the LCNG system		
Provide a kirk key in with gear for a generator (generator not included)		
No additional paving is included - only for back-filling/trenching		
Mics. Fees		
Engineering and Permitting Costs	$	117,655
Engineering and Design		
Engineering Consultant		
Programming		
Site Survey		
Permitting - does not include actual cost of permits		
Total Engineering & Permitting		
Equipment Scope		
1 x twin 150 hp IMW compressor package		
1 x priority panel		
1 x ASME storage vessel		
1 x single hose light duty dispenser		
1 x fuel support panel		
Reuse existing storage vessels		
2 x filters		
Total IMW Equipment	$	352,146
Total Non-IMW Equipment	$	132,519
Freight (could vary)	$	10,969
Project Admin/Overhead/Insurance/Start-up	$	55,033
Total East Valley CNG Project Installation	$	1,564,010

IMW equipment is specifically designed for the CNG vehicle fueling market. The compression chamber is oil free which provides the highest quality CNG in the industry. Clean Energy chose this equipment specifically for OmniTrans to reduce oil carryover into the buses. OmniTrans uses LNG to produce CNG thus avoiding Non Gaseous Liquids (NGL's) and oil in the pipeline natural gas fuel stream. Pipeline CNG is not as clean as LNG and therefore Clean Energy has selected IMW non-lubricated compressors for OmniTrans evaluation.



Transit Stations in Southern CA with IMW Equipment

LA Department of Transportation

The City of Torrance

TAB VII Schedule Feasibility

Scope of Work: Estimate the time necessary to complete construction of a fueling station that meets or exceeds the fuel requirements of OmniTrans.

Clean Energy estimates each project will take approximately eight (8) to twelve (12) months to engineer, design and build. The project schedule below illustrates the estimated timeline for each of the critical steps from design to startup and commissioning of a CNG station.

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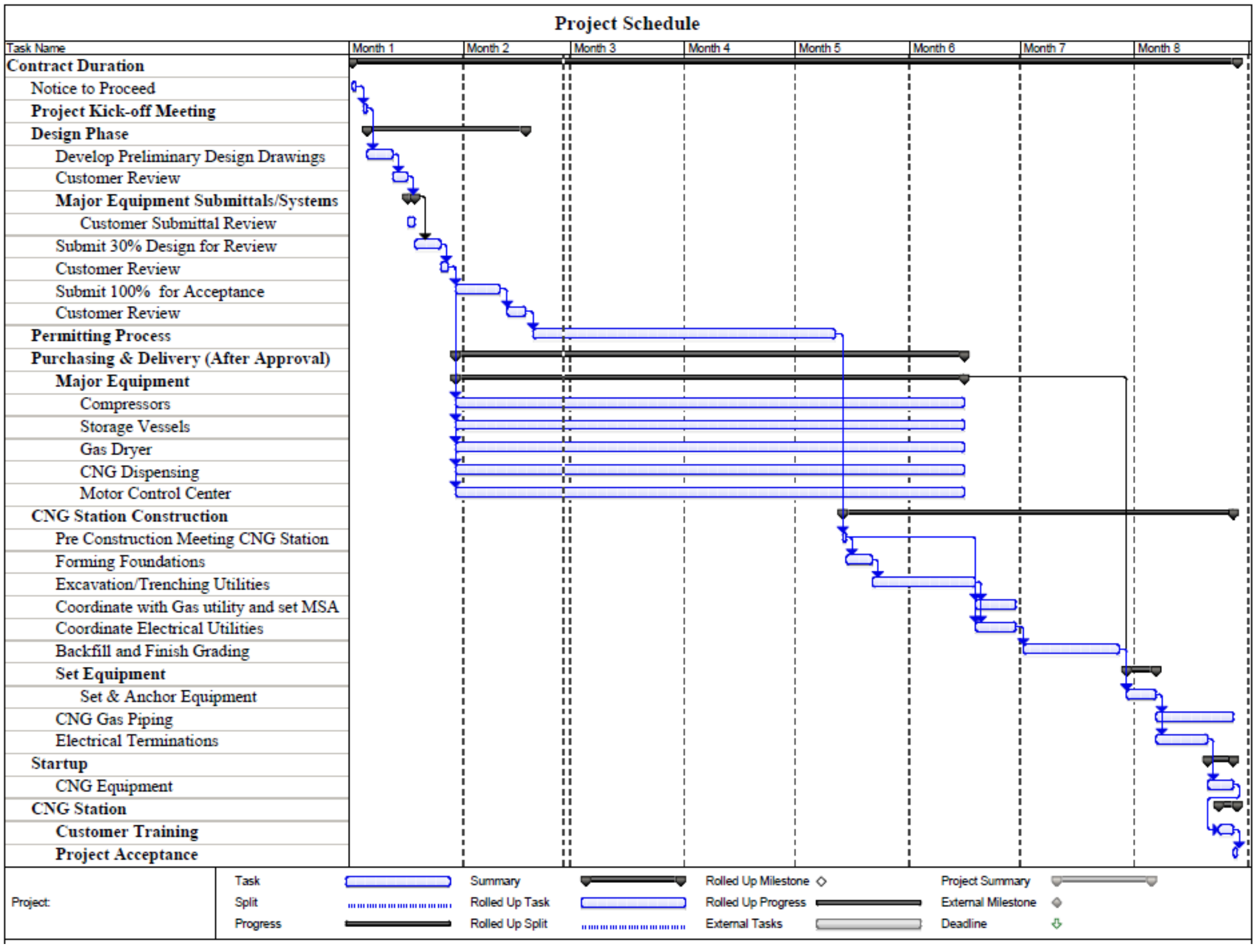

TAB VIII Market and Real Estate Feasibility

Evaluate OmniTrans' parcels for the best location for fueling station.

Clean Energy met with the OmniTrans' management team to evaluate site layouts and discussed the accommodation of the proposed CNG equipment and specific site improvements. The East Valley, West Valley and I Street facilities can easily accommodate installation and operation of CNG facilities within the existing footprints and at the same time, mitigate any noise, odor and/or operational concerns.

Additional property will not be required to install the proposed pipeline CNG infrastructure. The existing properties operated by OmniTrans have sufficient capacity to support current fueling operations and allow for the construction of new pipeline CNG systems. The following Conceptual Plans (CP) indicates the proposed equipment location for each facility.

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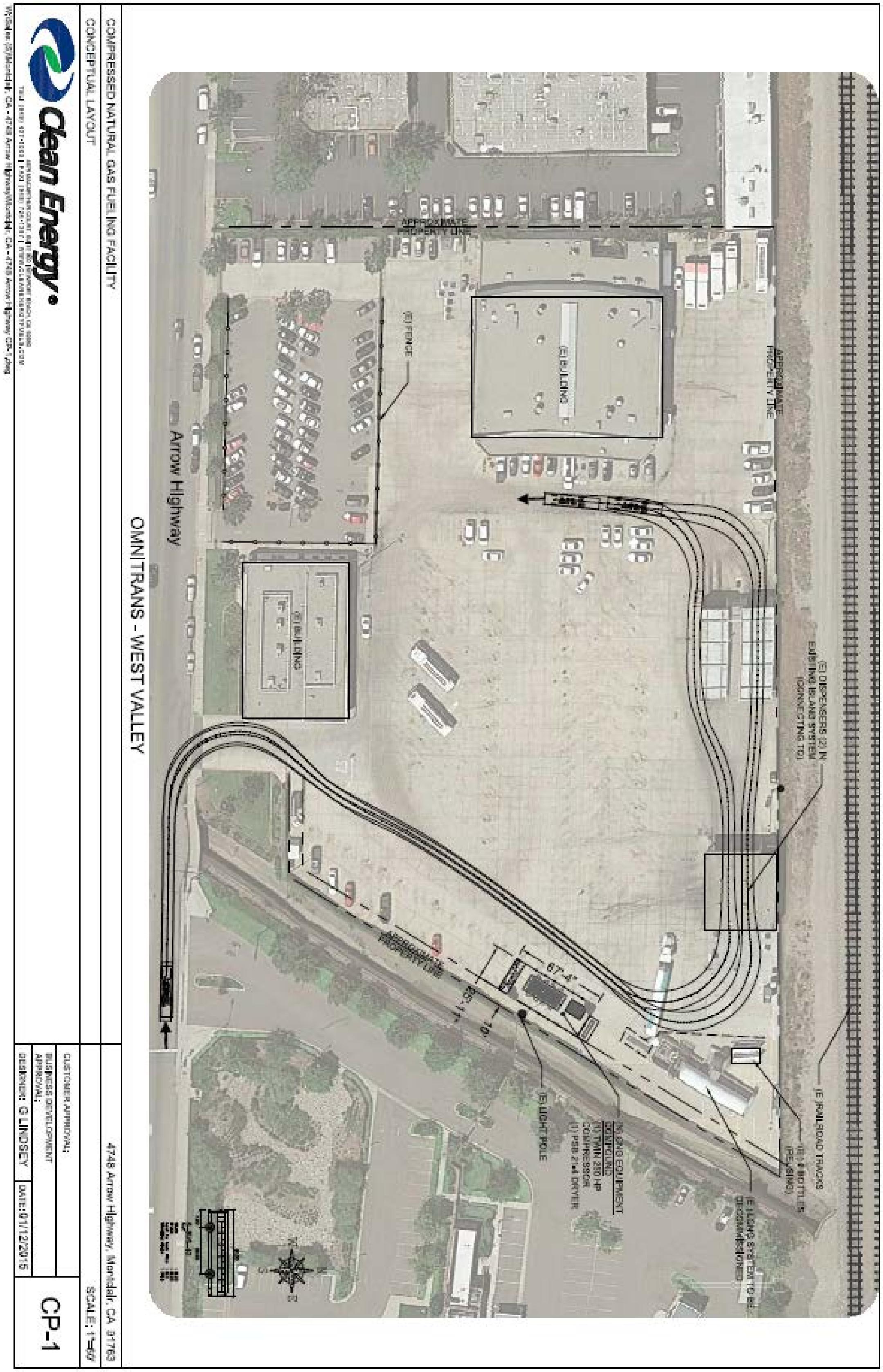
East Valley Facility

West Valley Facility



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I Street Paratransit Facility

TAB IX Resource Feasibility

Scope of Work: Evaluate the local utility's supply of natural gas and OmniTrans' requirement for bus fueling. Determine if construction of the fueling station will interfere with current day-to-day operations.

Clean Energy consulted with SoCal Gas Company to confirm adequate gas pressure and gas volume is available at each of the three sites; East Valley, West Valley and I Street. It was initially determined that a minimum of 25 psig is available at the meter set assembly (MSA) at each location. 25 psig will support the operation of the compression packages proposed for each location and will also support the flow/volume of gas needed to fuel buses within the necessary fueling windows. Higher gas pressure may ultimately be available but cannot be confirmed until a complete engineering analysis has been finalized by SoCal Gas. The SoCal Gas engineering estimate will follow the actual application for gas service, by OmniTrans.

To ensure uninterrupted service it is recommended OmniTrans adopt the following minimum requirements in any future solicitation:

- Quality Control Plan / Manual for project
- Health and Safety plans
- Install sound attenuation walls along perimeter of property near CNG station
- Require 24/7/365 monitoring by trained personal
- Emergency Response Plan
- Services/work that requires any interruption in gas or electric supply will be conducted during off-peak times for OmniTrans – exact hours to be established during installation
- Advise/work with OmniTrans with daily plans, goals and updates to minimize disruptions
- Require GENSET power during switch over to pipeline CNG station testing

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NGV PRELIMINARY SITE EVALUATION FORM

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(Continued inside)

SECTION 1: COMPLETED BY THE CUSTOMER

Name of Requesting Organization Clean Energy	Date January 14, 2015
Address of Requesting Organization 4675 MacArthur Court	ZIP Code 92660
Key Contact Name Sylvia Hendron	
Key Contact Telephone Number 949-437-9032	
Key Contact Email Address Sylvia.Hendron@cleanenergyfuels.com	
Name of End User Organization OmniTrans	
NGV Station Property Address[1] 1700 West 5th Street, San Bernardino	ZIP Code 92411
Closest Intersection or Cross Street West 5th Street	

	Scenario #1	Scenario #2	Scenario #3	Scenario #4
Maximum Flow Capacity Required, in standard cubic feet per minute (scfm):	1500	1750	**2000**	2500
Compressor Type:	☐Electric Driven or ☐Natural Gas Driven			
If compressor is natural gas-driven, provide natural gas engine maximum fuel consumption, in scfm:				
Potential for Future Growth?	☐ Yes or ☒ No *If Yes, provide detail (capacity in scfm and future year) in the "Comments" section below.*			
Comments:Click here to enter text.				

[1] A plot plan of the property should be provided with the location of the NGV refueling station, adjacent roads and desired gas meter location to avoid errors and delays.

SECTION 2: COMPLETED BY SOCALGAS

		Scenario #1	Scenario #2	Scenario #3	Scenario #4
Pressure District or Supply Line #:		SL 41-27	SL 41-27	SL 41-27	SL 41-27
Maximum Flow Capacity (scfm):		1500	1750	2000	2500
Estimated Inlet Pressure at Meter Set Assembly (MSA) (psig):	Minimum	100	101	100	98
	Winter	100	101	100	98
	Summer	104	106	105	103
Design Maximum Inlet Pressure at MSA (psig):		110	110	110	110
Estimated Outlet Pressure at MSA – Minimum (psig):		86	84	77	80
Estimated Service Diameter (inches) and Length (feet):		200 feet of 3" steel service	200 feet of 4" steel service	200 feet of 4" steel service	200 feet of 4" steel service
Estimated Main Diameter (inches) and Length (feet):		n/a	n/a	n/a	n/a
Comments:		Click here to enter text.	Click here to enter text.	Click here to enter text.	Click here to enter text.
Engineer Performing Review:		Nicole Cartwright			
Account Executive:		Click here to enter text.			
Account Executive Telephone Number:		Click here to enter text.			
Account Executive Email Address:		Click here to enter text.			
Date Received from Customer:		Click here to enter text.			
Date Returned to Customer:		Click here to enter text.			

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Address of Requesting Organization 4675 MacArthur Court	ZIP Code 92660
Key Contact Name Sylvia Hendron	
Key Contact Telephone Number 949-437-9032	
Key Contact Email Address Sylvia.Hendron@cleanenergyfuels.com	
Name of End User Organization OmniTrans	
NGV Station Property Address[1] 4748 Arrow Highway, Montclair, CA	ZIP Code 91763
Closest Intersection or Cross Street Arrow Highway	

	Scenario #1	Scenario #2	Scenario #3	Scenario #4
Maximum Flow Capacity Required, in standard cubic feet per minute (scfm):	1000	1250	**1500**	1800
Compressor Type:	☐Electric Driven or ☐Natural Gas Driven			
If compressor is natural gas-driven, provide natural gas engine maximum fuel consumption, in scfm:				
Potential for Future Growth?	☐ Yes or ☒ No *If Yes, provide detail (capacity in scfm and future year) in the "Comments" section below.*			
Comments:Click here to enter text.				

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SECTION 2: COMPLETED BY SOCALGAS

		Scenario #1	Scenario #2	Scenario #3	Scenario #4
Pressure District or Supply Line #:		41-34-A	41-34-A	41-34-A	41-34-A
Maximum Flow Capacity (scfm):		1000	1250	1500	1800
Estimated Inlet Pressure at Meter Set Assembly (MSA) (psig):	Minimum	198	197	195	194
	Winter	198	197	195	194
	Summer	223	222	221	220
Design Maximum Inlet Pressure at MSA (psig):		230	230	230	230
Estimated Outlet Pressure at MSA – Minimum (psig):		177	177	167	175
Estimated Service Diameter (inches) and Length (feet):		Reinstate, the previously abandoned 485 feet of 3” Steel service, it is sufficient	Reinstate, the previously abandoned 485 feet of 3” Steel service, it is sufficient	Reinstate, the previously abandoned 485 feet of 3” Steel service, it is sufficient	Reinstate, the previously abandoned 485 feet of 3” Steel service , it is sufficient
Estimated Main Diameter (inches) and Length (feet):		n/a	n/a	n/a	n/a
Comments:		Reinstate, the previously abandoned 485 feet of 3” Steel service, it is sufficient to provide 1000 scfm	Reinstate, the previously abandoned 485 feet of 3” Steel service, it is sufficient to provide 1250 scfm	Reinstate, the previously abandoned 485 feet of 3” Steel service, it is sufficient to provide 1500 scfm	Reinstate, the previously abandoned 485 feet of 3” Steel service, it is sufficient to provide1800 scfm
Engineer Performing Review:		Edgar Muller			
Account Executive:		Click here to enter text.			
Account Executive Telephone Number:		Click here to enter text.			
Account Executive Email Address:		Click here to enter text.			
Date Received from Customer:		Click here to enter text.			
Date Returned to Customer:		Click here to enter text.			

Southern California Gas Company

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NGV PRELIMINARY SITE EVALUATION FORM

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Key Contact Name Sylvia Hendron	
Key Contact Telephone Number 949-437-9032	
Key Contact Email Address Sylvia.Hendron@cleanenergyfuels.com	
Name of End User Organization OmniTrans	
NGV Station Property Address[1] 234 South I Street, San Bernardino	ZIP Code 92410
Closest Intersection or Cross Street South I Street	

	Scenario #1	Scenario #2	Scenario #3	Scenario #4
Maximum Flow Capacity Required, in standard cubic feet per minute (scfm):	500	750	**1000**	1250
Compressor Type:	☐Electric Driven or ☐Natural Gas Driven			
If compressor is natural gas-driven, provide natural gas engine maximum fuel consumption, in scfm:				
Potential for Future Growth?	☐ Yes or ☒ No *If Yes, provide detail (capacity in scfm and future year) in the "Comments" section below.*			

Comments:Click here to enter text.

[1] A plot plan of the property should be provided with the location of the NGV refueling station, adjacent roads and desired gas meter location to avoid errors and delays.

SECTION 2: COMPLETED BY SOCALGAS

		Scenario #1	Scenario #2	Scenario #3	Scenario #4
Pressure District or Supply Line #:		41032	41032	41032	41032
Maximum Flow Capacity (scfm):		500	750	1000	1250
Estimated Inlet Pressure at Meter Set Assembly (MSA) (psig):	Minimum	27	29	31	28
	Winter	27	29	32	28
	Summer	35	36	38	35
Design Maximum Inlet Pressure at MSA (psig):		45	45	45	45
Estimated Outlet Pressure at MSA – Minimum (psig):		16	22	22	21
Estimated Service Diameter (inches) and Length (feet):		325 feet of 3" PE service	325 feet of 4" PE service	325 feet of 4" PE service	325 feet of 6" PE service
Estimated Main Diameter (inches) and Length (feet):		n/a	n/a	n/a	n/a
Comments:		Approx. 250 feet of main will need to be installed across a wash in order to serve this customer	Approx. 1625 feet of main will need to be installed/ upsized in order to serve this customer	Approx. 1625 feet of main will need to be installed/ upsized in order to serve this customer	Approx. 1625 feet of main will need to be installed/ upsized in order to serve this customer
Engineer Performing Review:		Nicole Cartwright			
Account Executive:		Click here to enter text.			
Account Executive Telephone Number:		Click here to enter text.			
Account Executive Email Address:		Click here to enter text.			
Date Received from Customer:		Click here to enter text.			
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Address of Requesting Organization 4675 MacArthur Court	ZIP Code 92660
Key Contact Name Sylvia Hendron	
Key Contact Telephone Number 949-437-9032	
Key Contact Email Address Sylvia.Hendron@cleanenergyfuels.com	
Name of End User Organization OmniTrans	
NGV Station Property Address[1] 9421 Feron Blvd, Rancho Cucamonga, CA	ZIP Code 91730
Closest Intersection or Cross Street Feron Blvd	

	Scenario #1	Scenario #2	Scenario #3	Scenario #4
Maximum Flow Capacity Required, in standard cubic feet per minute (scfm):	500	750	**1000**	1250
Compressor Type:	☐Electric Driven or ☐Natural Gas Driven			
If compressor is natural gas-driven, provide natural gas engine maximum fuel consumption, in scfm:				
Potential for Future Growth?	☐ Yes or ☒ No *If Yes, provide detail (capacity in scfm and future year) in the "Comments" section below.*			

Comments:Click here to enter text.

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SECTION 2: COMPLETED BY SOCALGAS

		Scenario #1	Scenario #2	Scenario #3	Scenario #4
Pressure District or Supply Line #:		41062	41062	41062	41062
Maximum Flow Capacity (scfm):		500	750	1000	1250
Estimated Inlet Pressure at Meter Set Assembly (MSA) (psig):	Minimum	34	27	32	29
	Winter	34	27	33	29
	Summer	37	30	36	32
Design Maximum Inlet Pressure at MSA (psig):		45	45	45	45
Estimated Outlet Pressure at MSA – Minimum (psig):		24	16	23	22
Estimated Service Diameter (inches) and Length (feet):		Approx. 350 feet of 3" PE service	Approx. 350 feet of 4" PE service	Approx. 350 feet of 4" PE service	Approx. 350 feet of 6" PE service
Estimated Main Diameter (inches) and Length (feet):		n/a	n/a	n/a	n/a
Comments:		Approx. 1225 feet of 2" PE main will need to be upsized to minimum 3" PE main	Approx. 1225 feet of 2" PE main will need to be upsized to minimum 3" & 4" PE main	Approx. 1975 feet of 2" & 3" main will need to be upsized to minimum 4" PE main	Approx. 1975 feet of 2" & 3" main will need to be upsized to minimum 4" & 6" PE main
Engineer Performing Review:		Nicole Cartwright			
Account Executive:		Click here to enter text.			
Account Executive Telephone Number:		Click here to enter text.			
Account Executive Email Address:		Click here to enter text.			
Date Received from Customer:		Click here to enter text.			
Date Returned to Customer:		Click here to enter text.			

(Continued on back)

OmniTrans Connecting Our Community. Clean Energy

TAB X Financial Feasibility

Scope of Work: Evaluate the fueling station financial viability on the total estimated cost of the fueling station, including existing land and/or equipment and details of land and/or equipment to be purchased.

Based on estimated annual savings of $760k at East Valley and $460k at West Valley and $137k at the Paratransit site (total = $1,350,000) OmniTrans can reduce fuel expenditures by an estimated $13,500,000 million over the next ten (10) years by switching to pipeline CNG. This figure does not include the cost to design, build, operate, maintain and finance three (3) private pipeline CNG stations to serve both the fixed route and Paratransit fleets. Details of these projected savings are detailed in the tabs above.

OmniTrans

Pipeline CNG Feasibility Study Review

05.06.15

Agenda

- Site Summaries
- Legal Feasibility
- Operational Feasibility
- Economic Feasibility
- Technical Feasibility
- Schedule Feasibility
- Market & Real Estate Feasibility
- Resource Feasibility
- Financial Feasibility

Site Summaries

- East Valley – 118 bus fleet – 90 active – 2 x 30,000 LNG tanks – secure11 days fuel storage – average bus 45.9 GGE day
- West Valley – 63 bus fleet – 54 active – 2 x 30,000 LNG tanks – secure 20 days fuel storage – average bus 47.5 GGE day
- I Street Paratransit Fleet – 62 bus fleet – 44 active – average bus 20.2 GGE per day – total fuel volume 450,000 gallons per year

Legal Feasibility

- Clean Energy consulted with our internal legal and permitting departments regarding the installation of a pipeline CNG station at the OmniTrans fueling facilities. Clean Energy did not find any specific legal impediments preventing OmniTrans from moving forward with a pipeline CNG station.

- Any and all design and implementation must comply with all applicable codes and standards for safety, fire, health and local requirements such as The National Fire Protection Agency Code 52 (NFPA52). This code covers the design, installation, operation, and maintenance of CNG and LNG fuel systems on all vehicle types plus their respective compression, storage, and dispensing systems.

Operational Feasibility

Pipeline CNG		L/CNG		Gasoline	
Commodity Cost	$ 0.5100	Commodity Cost	$ 1.2800	Commodity Cost	$ 2.2500
Electricity	$ 0.2000	Electricity	$ 0.1000	Electricity	$ -
O&M	$ 0.2500	O&M	$ 0.1000	O&M	$ -
Taxes	$ 0.0100	Taxes	$ 0.0100	Taxes	$ -
SoCal Gas Transportation Rate	$ 0.1624	CA Tax	$ 0.0825		
Capital Cost (unknown)	$ -	Capital Costs (zero)	$ -	Capital Cost (unknown)	$ -
Total Cost Pipeline CNG	$ 1.1324	Total Cost L/CNG	$ 1.5725	Total Cost Gasoline	$ 2.2500

NOTES:
Pipeline CNG = So Cal Gas NGV1 rate Q4 2014 $4.06 / 8 = $0.51 cents per GGE
L/CNG = So Cal Gas rate $4.06 / 12.1 + $0.5168 = $0.8523 x 1.5 (convert to GGE) = $1.28 cost per L/CNG gallon converted to GGE
Gasoline - prices are at record lows. Industry experts expect prices to remain low until Q3 of 2015 when over supply is corrected.

The savings per gallon for pipeline CNG compared to LCNG is approximately $0.44 cents per GGE and approximately $1.12 when compared to gasoline. Please note the commodity cost for pipeline CNG is much lower than LCNG due to the lower energy content per LNG gallon. However they both start with a base rate of $4.06 per MMBTU

Operational Feasibility

East Valley		
Annual Fuel Volume		1,728,000
Pipeline CNG Fuel Savings (per gallon)	$	0.44
Annual Operational Budget Savings	$	760,320.00

West Valley		
Annual Fuel Volume		1,056,000
Pipeline CNG Fuel Savings (per gallon)	$	0.44
Annual Operational Budget Savings	$	464,640.00

Paratransit Operations		
Annual Fuel Volume		122,748
Pipeline CNG Fuel Savings (per gallon)	$	1.12
Annual Operational Budget Savings	$	137,477.76

Economic Feasibility / East Valley

Omnitrans ROI Forecast / East Valley Fleet

Prices	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Natural Gas Prices										
Henry Hub Spot Price / highest baseline	$4.06	$4.16	$4.26	$4.36	$4.46	$4.57	$4.68	$4.79	$4.91	$5.03
Gasoline Gallon Equivalent Price	$0.51	$0.52	$0.53	$0.54	$0.56	$0.57	$0.59	$0.60	$0.61	$0.63
Capital Recovery is not included										
Station Maintenance 100% Parts / Labor	$0.250	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500
Electricity & Communications	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000
State Taxes (if applicable)	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100
SoCal Gas Transportation rate	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624
Total Price per GGE	$1.1299	$1.1421	$1.1546	$1.1673	$1.1804	$1.1938	$1.2075	$1.2216	$1.2359	$1.2507
LCNG cost/GGE (includes $.0825 tas)	$1.5725	$1.5825	$1.5925	$1.6025	$1.6225	$1.6325	$1.6525	$1.6625	$1.6725	$1.6925
Cost Savings per Gallon (CNG vs. LCNG)	**$0.4426**	**$0.4404**	**$0.4379**	**$0.4352**	**$0.4421**	**$0.4387**	**$0.4450**	**$0.4409**	**$0.4366**	**$0.4418**
Total CNG Buses in Fleet	90	90	90	90	90	90	90	90	90	90
Total Annual Fuel Savings	**$501,717**	**$761,046**	**$756,774**	**$751,984**	**$763,945**	**$758,084**	**$768,947**	**$761,961**	**$754,393**	**$763,509**
Total Cumulative Fuel Savings	**$501,717**	**$1,262,763**	**$2,019,537**	**$2,771,521**	**$3,535,466**	**$4,293,549**	**$5,062,496**	**$5,824,457**	**$6,578,851**	**$7,342,359**
Annual LNG consumption per bus	**19,200**									

NOTES:

90 Active Bus Fleet

Fuel Savings are Cumulative

Clean Energy has estimated the cost of capital for OmniTrans based on standard lease rate; seven (7) years with 4.25% interest. The installation of a pipeline CNG station for the East Valley facility will cost an estimated $2.3 million or approximately $0.20 cents per gallon.

Economic Feasibility / West Valley

Omnitrans ROI Forecast / West Valley Fleet

Prices	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Natural Gas Prices										
Henry Hub Spot Price / highest baseline	$4.06	$4.16	$4.26	$4.36	$4.46	$4.57	$4.68	$4.79	$4.91	$5.03
Gasoline Gallon Equivalent Price	$0.51	$0.52	$0.53	$0.54	$0.56	$0.57	$0.59	$0.60	$0.61	$0.63
Capital Recovery is not included										
Station Maintenance 100% Parts / Labor	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500	$0.2500
Electricity & Communications	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000	$0.2000
State Taxes (if applicable)	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100	$0.0100
SoCal Gas Transportation Rate	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624	$0.1624
Total Price per GGE	$1.1299	$1.1421	$1.1546	$1.1673	$1.1804	$1.1938	$1.2075	$1.2216	$1.2359	$1.2507
L/CNG cost	$1.5725	$1.5825	$1.5925	$1.6025	$1.6225	$1.6325	$1.6525	$1.6625	$1.6725	$1.6925
Cost Savings per Gallon (CNG vs. Gas)	**$0.4426**	**$0.4404**	**$0.4379**	**$0.4352**	**$0.4421**	**$0.4387**	**$0.4450**	**$0.4409**	**$0.4366**	**$0.4418**
Total CNG Buses in Fleet	63	63	63	63	63	63	63	63	63	63
Total Annual Fuel Savings	**$467,386**	**$465,084**	**$462,473**	**$459,546**	**$466,855**	**$463,273**	**$469,912**	**$465,643**	**$461,018**	**$466,589**
Total Cumulative Fuel Savings	**$467,386**	**$932,469**	**$1,394,942**	**$1,854,488**	**$2,321,343**	**$2,784,616**	**$3,254,528**	**$3,720,171**	**$4,181,189**	**$4,647,778**
Annual Fuel Consumption (per bus)	**16,762**									

NOTES:

63 Active Bus Fleet

Fuel Savings are Cumulative

The cost to install a pipeline CNG station at the West Valley facility will be an estimated $1.7 million or $0.30 cents per GGE.

Economic Feasibility / I Street Paratransit

Omnitrans ROI Forecast / Paratransit Fleet

Prices	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Natural Gas Prices										
Henry Hub Spot Price / highest baseline	$4.06	$4.16	$4.26	$4.36	$4.46	$4.57	$4.68	$4.79	$4.91	$5.03
Gasoline Gallon Equivalent Price	$0.51	$0.52	$0.53	$0.54	$0.56	$0.57	$0.59	$0.60	$0.61	$0.63
Capital Recovery is not included										
Station Maintenance 100% Parts / Labor	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
Electricity & Communications	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
State Taxes (if applicable)	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
SoCal Gas Transportation Rate	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16
Total Price per GGE	$1.13	$1.14	$1.15	$1.17	$1.18	$1.19	$1.21	$1.22	$1.24	$1.25
EIA Gasoline Price / lowest baseline	$2.25	$2.35	$2.45	$2.55	$2.65	$2.75	$2.85	$2.95	$3.05	$3.15
Cost Savings per Gallon (CNG vs. Gas)	**$1.12**	**$1.29**	**$1.38**	**$1.47**	**$1.55**	**$1.64**	**$1.72**	**$1.81**	**$1.90**	**$1.90**
Total CNG Buses in Fleet	12	24	36	44	44	44	44	44	44	44
Total Annual Fuel Savings	**$137,490**	**$316,793**	**$507,421**	**$659,441**	**$698,562**	**$737,542**	**$776,378**	**$815,065**	**$853,601**	**$854,850**
Total Cumulative Fuel Savings	**$137,490**	**$454,283**	**$961,704**	**$1,621,145**	**$2,319,707**	**$3,057,249**	**$3,833,626**	**$4,648,691**	**$5,502,292**	**$6,357,142**
Annual Fuel Consumption (per bus)	**10,229**									

NOTES:

110 Unit Paratransit Fleet

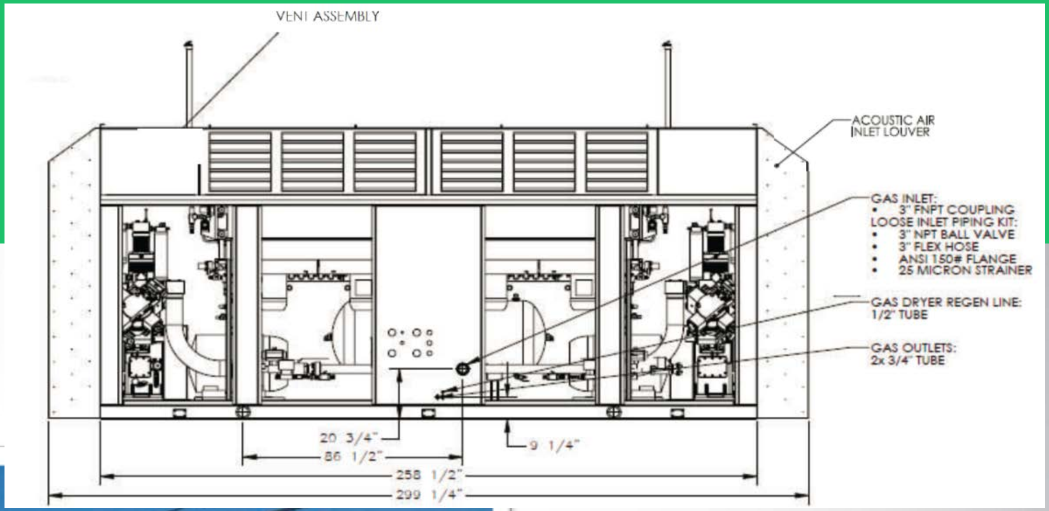
Fuel Savings are Cumulative

The cost to install a pipeline CNG station at the I Street Paratransit facility will be an estimated $1.5 million or $0.65 cents per GGE.

Technical Feasibility

- East Valley Facility – 2140 SCFM – 1070 gallons per hour – station cost $2.294 M
- West Valley Facility – 1070 SCFM – 535 gallons per hour – station cost $1.708 M
- Paratransit Facility I Street – 526 SCFM – 263 gallons per hour – station cost $1.564 M

Technical Feasibility



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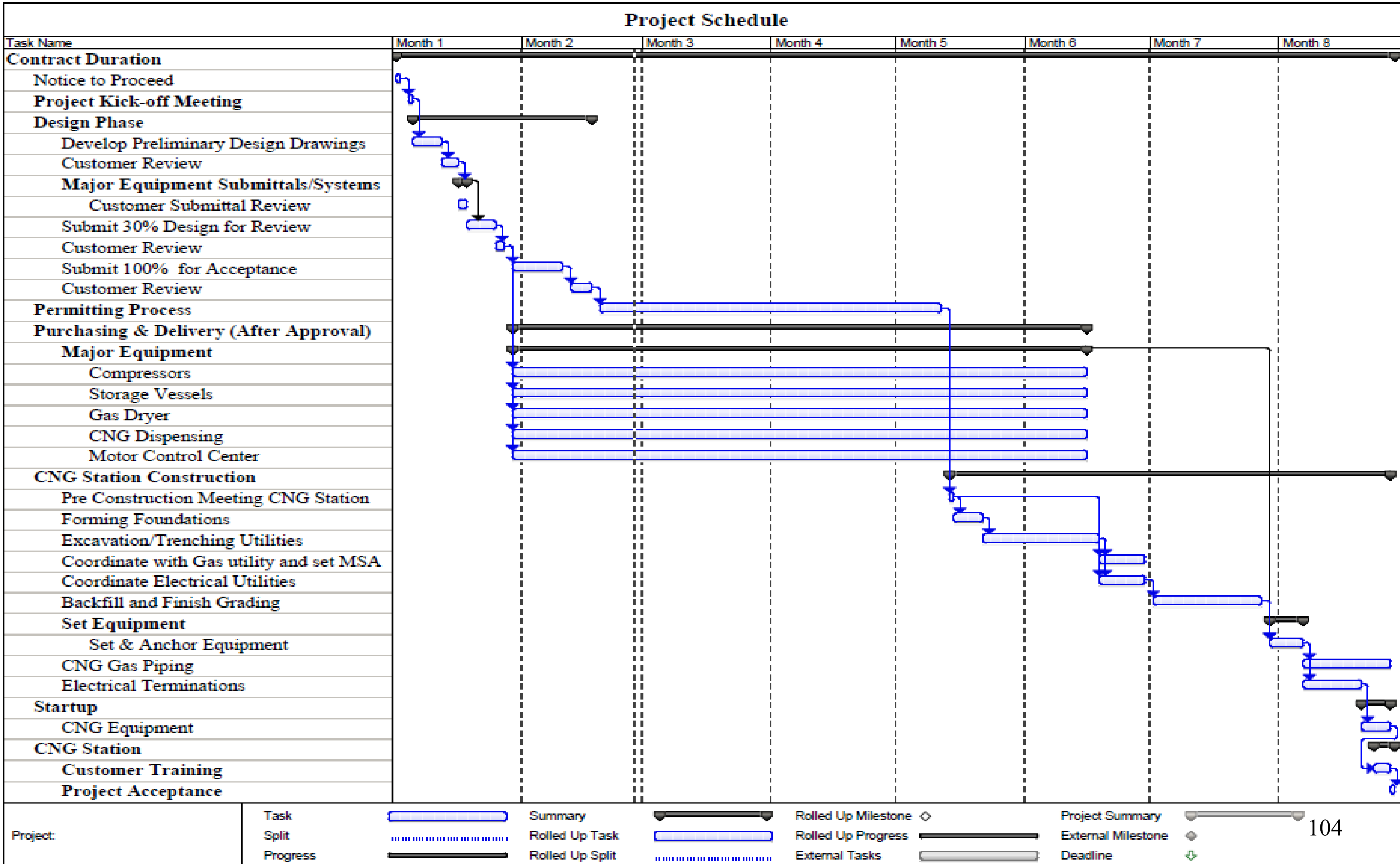
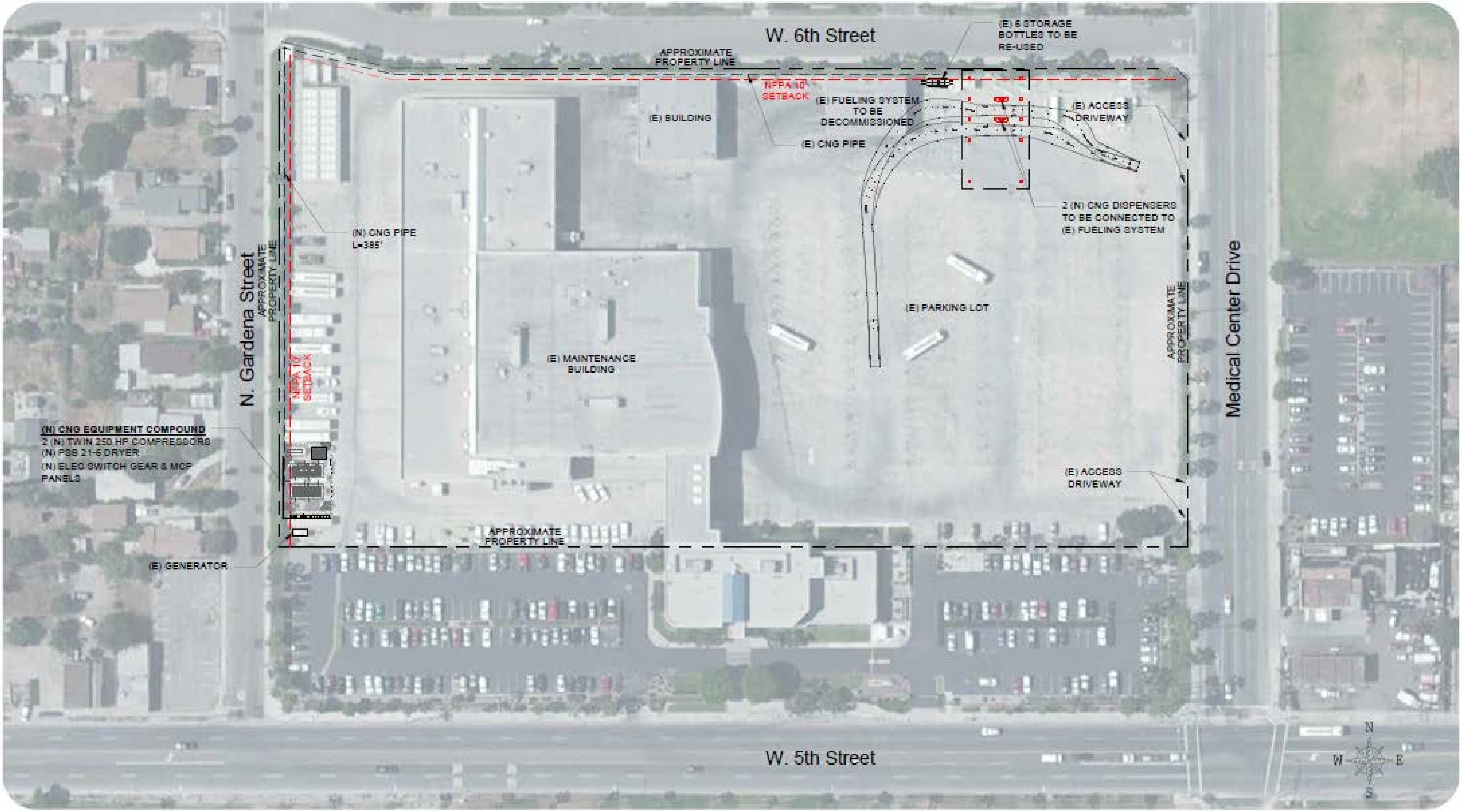
Schedule Feasibility



Market & Real Estate Feasibility / East Valley



OMNITRANS - EAST VALLEY

COMPRESSED NATURAL GAS FUELING FACILITY	1700 West 5th Street, San Bernardino, CA 92411
CONCEPTUAL LAYOUT	SCALE: 1"=80'

Clean Energy®

4675 MACARTHUR COURT, SUITE 800 | NEWPORT BEACH, CA 92660
TEL: (949) 437-1000 | FAX: (949) 724-1397 | WWW.CLEANENERGYFUELS.COM

CUSTOMER APPROVAL:

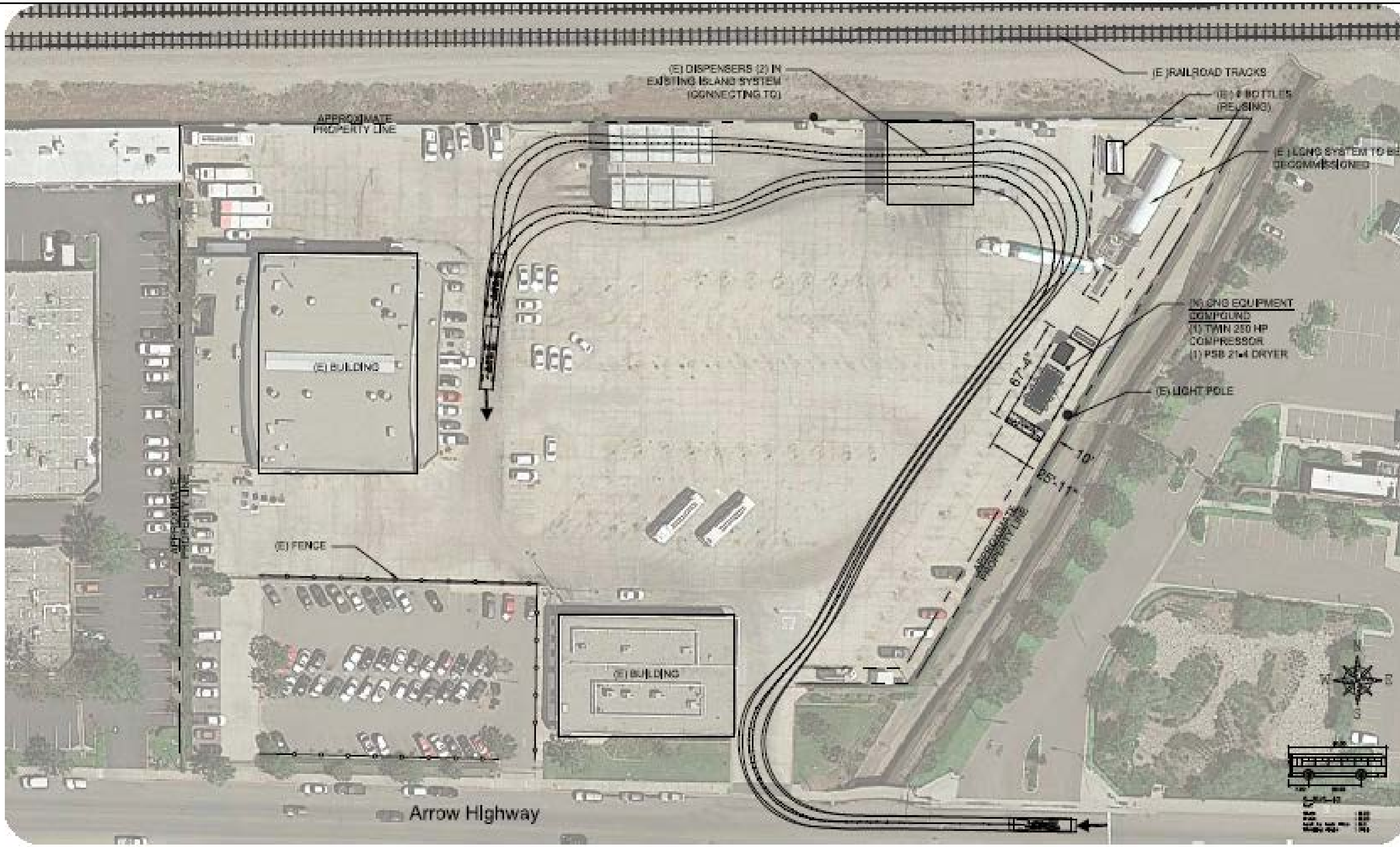
BUSINESS DEVELOPMENT APPROVAL:

DESIGNER: HV Tran

DATE: 01/27/2015

CP-1

Market & Real Estate Feasibility / West Valley



OMNITRANS - WEST VALLEY

COMPRESSED NATURAL GAS FUELING FACILITY	4748 Arrow Highway, Montclair, CA 91763
CONCEPTUAL LAYOUT	SCALE: 1"=60'

Clean Energy

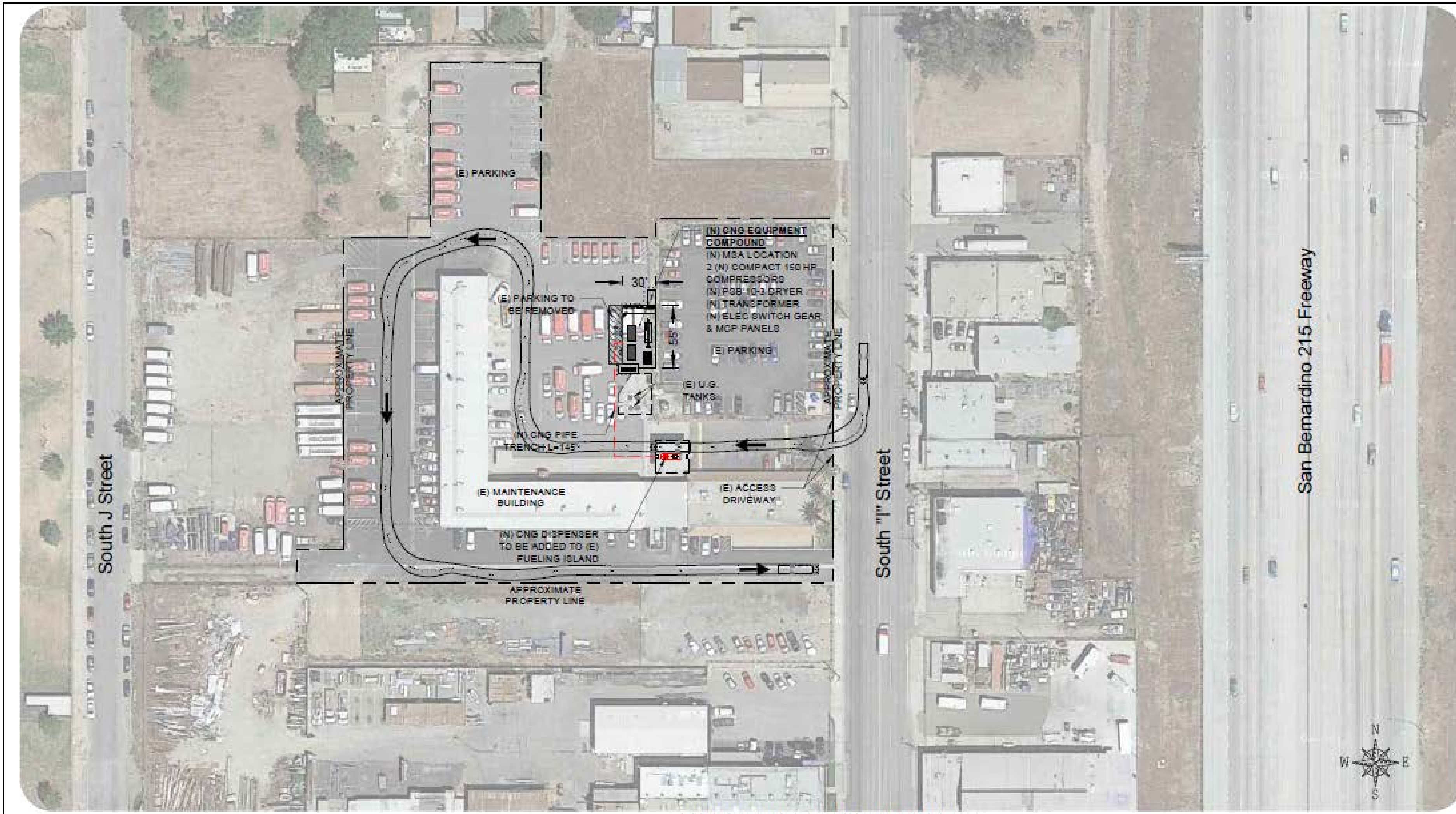
CUSTOMER APPROVAL:

BUSINESS DEVELOPMENT APPROVAL:

DESIGNER: G LINDSEY | DATE: 01/12/2015

CP-1

Market & Real Estate Feasibility / I Street



OMNITRANS - SOUTH "I" STREET

COMPRESSED NATURAL GAS FUELING FACILITY	234 South I Street, San Bernardino, CA 92410
CONCEPTUAL LAYOUT	SCALE: 1"=80'

Clean Energy®

4675 MACARTHUR COURT, SUITE 800 | NEWPORT BEACH, CA 92660
TEL: (949) 437-1000 | FAX: (949) 724-1397 | WWW.CLEANENERGYFUELS.COM

CUSTOMER APPROVAL:

BUSINESS DEVELOPMENT APPROVAL:

DESIGNER: HV Tran | DATE: 01/12/2015

CP-1

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Resource Feasibility

- East Valley 100 PSIG
- West Valley 197 PSIG
- I Street Paratransit 29 PSIG

Financial Feasibility

TAB X Financial Feasibility

Scope of Work: Evaluate the fueling station financial viability on the total estimated cost of the fueling station, including existing land and/or equipment and details of land and/or equipment to be purchased.

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