NYSDEC OHMS Document No. 201166576-00030

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Application of Finger Lakes LPG Storage, LLC

Application No. 8-4432-00085

FINGER LAKES LPG STORAGE, LLC'S RESPONSE TO PARTY STATUS PETITIONS

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I. Introduction

Pursuant to the schedule established in the Notice of Extension of Deadline for Petitions for Party Status, Finger Lakes LPG Storage, LLC ("Finger Lakes LPG Storage" or the "Applicant") submits this memorandum in response to the Petitions for Party Status filed by Gas Free Seneca, Seneca Lake Pure Water Association ("SLPWA"), the Seneca Lake Communities, the Finger Lakes Wine Business Coalition, and County Legislators Harp and Lausell (collectively, the "Petitioners").[1] Finger Lakes LPG Storage has applied for a permit to construct and operate a new liquefied petroleum gas ("LPG") storage facility for the storage and distribution of propane and butane on a portion of a 576-acre parcel in the Town of Reading, Schuyler County (the "Project"). Based on the contents of the Petitions for Party Status, the application and related documents, the draft permit, and the written submittals presented by the Applicant, Petitioners have failed to raise any issues for adjudication. As conditioned in the draft permit, the Applicant has shown that it will meet the statutory and regulatory criteria applicable to the Project and that therefore there are no adjudicable issues and the permit for the Project should be issued.

II. Petitioners cannot satisfy their Burden that Substantive and Significant Issues Exist

The standard for what constitutes an adjudicable issue is found in Part 624 and the context within which a ruling must be made has been consistently established in DEC administrative precedent. Pursuant to 6 NYCRR Part 624, an issue is adjudicable where:

(i) "it relates to a dispute between the department staff and the applicant over a substantial term or condition of the draft permit;

(ii) "it relates to a matter cited by the department staff as a basis to deny the permit and is contested by the applicant; or

[1] The Finger Lakes Wine Business Coalition and CountyLegislators Harp and Lausell have sought Amicus Status. For the reasons stated in this memo, their Petitions should also be denied.

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(iii) "it is proposed by a potential party and is both substantive and significant." 6 NYCRR § 624.4(c)(1)(i-iii).

Where contested issues are proposed by third parties, an issue must be both substantive and significant to be adjudicable. 6 NYCRR § 624.4(c)(1)(iii). An issue is substantive if there is sufficient doubt about the applicant's ability to meet statutory or regulatory criteria applicable to the project, such that a reasonable person would require further inquiry. An issue is significant "if it has the potential to result in the denial of a permit, a major modification to the proposed project or the imposition of significant permit conditions in addition to those proposed in the draft permit." 6 NYCRR § 624.4(c)(3).

Where Department Staff has determined that an applicant's project, as proposed or as conditioned by the draft permit, conforms to all applicable requirements of statute and regulation, "the burden of persuasion is on a potential party proposing an issue to demonstrate that it is both substantive and significant." 6 NYCRR § 624.4(c)(4). *See also Matter of Seneca Meadows, Inc.*, Interim Decision, October 26, 2012. Here, Department Staff issued a draft permit on November 14, 2014, and therefore the burden of persuasion is on the Petitioners to demonstrate that an issue is substantive and significant. Petitioners have failed to satisfy their burden of persuasion that any issue exists for adjudication, in light of the Application and all other documents on the record, the documents submitted herewith, the law, and established DEC administrative precedent.

In order to participate as a party in a Part 624 proceeding on a permit application, the potential party must file a petition in writing that, among other things, identifies the precise grounds for opposition and support. See 6 NYCRR § 624.5(b)(1)(v). To the contrary, while the petitions submitted in this proceeding purportedly identify, quite speculatively in many cases, concerns with cavern integrity, safety, economics, noise and community character, what is

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missing is any link to how these speculative observations relate to the ability of the Applicant to comply with applicable laws and regulations, particularly as the Project is conditioned in the draft permit.

In determining whether a Petitioner has identified an issue for adjudication, the ALJ must consider "the proposed issue in light of the application and related documents, the draft permit, the content of any petitions filed for party status, the record of the issues conference and any subsequent written arguments authorized by the ALJ." 6 NYCRR § 624.4(c)(2). *See also Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC (SPDES)*, Interim Decision, August 13, 2008; *Matter of Seneca Meadows, Inc.*, Interim Decision, October 26, 2012.

An offer of proof may be rebutted by the application, the draft permit and proposed conditions, Department staff's analysis, the SEQRA documents, the record of the issues conference, and authorized briefs, among other relevant materials and arguments. See *Matter of Thalle Industries, Inc*., Decision of the Deputy Commissioner, November 3, 2004, at 19-20. Each of the reports submitted herewith on their own completely rebut the often speculative assertions made by the reports submitted by the Petitioners.

Moreover, in areas of Department staff's expertise, its evaluation is an important consideration in determining whether an issue is adjudicable. *See Matter of Halfmoon Water Improvement Area No. 1*, Decision of the Commissioner, April 2, 1982, at 2; *Matter of Bonded Concrete, Inc*., Interim Decision of the Commissioner, June 4, 1990, at 2. Judgments about the strength of the offer of proof must be made, among other things, in the context of the analysis of Department staff. *See Matter of NYC Department of Sanitation [Southwest Brooklyn Marine Transfer Station]*, Decision of the Commissioner, May 21, 2012, at 5; *Matter of Mirant Bowline,*

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LLC, Interim Decision of the Commissioner, June 20, 2001, at 3; *Matter of Seneca Meadows, Inc.*, Interim Decision, October 26, 2012, at 3. Here, Department Staff has issued a draft permit which reflects that conclusion on the part of Staff that the Finger Lakes LPG Storage Project has satisfied the Environmental Conservation Law. In addition, it should not be forgotten that another State agency representative, the State Geologist, has concluded that the Applicant's "demonstration of both cap rock and cavern integrity is complete, and with a properly developed monitoring program, Finger Lakes LPG Storage's proposed use of the Salt Point caverns is geologically sound. Further, in our review of the application materials, it has been demonstrated that the caverns in this salt formation have a longstanding operational record as a gas storage facility without any geologic evidence of incompatibility for this intended purpose." See Hearing Document I.A.25.

The submission of a petition for party status is not a pro forma exercise. Conducting an adjudicatory hearing "where 'offers of proof, at best, raise potential uncertainties' or where such a hearing 'would dissolve into an academic debate' is not the intent of the Department's hearing process" *Matter of Adirondack Fish Culture Station*, Interim Decision of the Commissioner, August 19, 1999, at 8 (quoting *Matter of AKZO Nobel Salt Inc.*, Interim Decision of the Commissioner, January 31, 1996, at 12); *Matter of Seneca Meadows, Inc.*, Interim Decision, October 26, 2012, at 4.

Where SEQRA issues are being challenged, the ALJ must determine whether Department staff identified the relevant areas of environmental concern, took a hard look at them, and made a reasoned elaboration of the basis for its determination. *See Matter of Metro Recycling & Crushing, Inc.*, Decision of the Commissioner, April 21, 2005, at 6 (citing *Matter of Chemical Specialties Manufacturers Assoc. v. Jorling*, 85 N.Y.2d 382, 396-97 (1995)). If Department

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staff's conclusion is "reasonable and supported by the record, it will be upheld" (*Matter of Metro Recycling & Crushing, Inc.*, at 6), and a substantive and significant issue will not be found. Furthermore, SEQRA does not require the Department to use the adjudicatory forum to resolve or otherwise address comments on the DEIS where substantive and significant issues are not raised. *See, e.g., Matter of Wilmorite, Inc.*, Interim Decision of the Commissioner, October 7, 1981, at 3-4; *Matter of Seneca Meadows, Inc.*, Interim Decision, October 26, 2012, at 4-5.

III. There is No Basis to Adjudicate the Project's Impact on Community Character

Several petitioners offer as an issue for adjudication the DSEIS's alleged insufficient analysis of the Project's impacts on regional "community character." Most specifically, petitioners contend that the Project's "industrialization" of the Finger Lakes and resulting harm to regional wine tourism are not adequately analyzed in the DSEIS. Petitioners' community character arguments are legally and factually devoid of merit in multiple respects and do not represent an adjudicable issue.

A. Community Character Cannot Be Adjudicated as a Separate Issue

As a threshold matter, it is well established that community character is not adjudicable as a separate issue. Because "impacts on community character are often intertwined with other environmental issues and can be addressed in the context of those specific issues…community character is not readily susceptible to adjudication as a separate issue but rather is considered after the record is developed on particular environmental issues which are aspects of overall community character." *Crossroads Ventures, LLC*, Interim Decision of the Deputy Commissioner, 2006 WL 3873403, *26 (NYSDEC 2006); *see Red Wing Properties, Inc.*, Interim Decision of the Commissioner, 2010 WL 3366172, *6 (NYSDEC 2010) (rejecting community character as an issue for adjudication "because impacts to community character are implicated in other issues for adjudication – noise, visual, and traffic impacts" and "the record on community

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character can be further developed through those issues"); *St. Lawrence Cement Co., LLC*, Second Interim Decision of the Commissioner, 2004 WL 2026420, *49-50 (NYSDEC 2004) (focusing adjudication on discrete environmental issues – visual impacts and air quality impacts – rather than on general issue of community character).[2] Remarkably, petitioners do not even address this controlling precedent on the lack of community character as a cognizable substantive and significant issue in their several petitions.

Here, petitioners' community character arguments are entirely based on other environmental issues – visual, traffic, noise, and safety impacts – that are comprehensively and adequately analyzed in the DSEIS, its appendices, and related study documents, and the sufficiency of those analyses is also addressed elsewhere in this document.[3] Because each of those other environmental issues are theoretically subject to adjudication in their own right (although there is no basis for adjudication of any of those issues in this proceeding), community character cannot be adjudicated as a separate issue.

B. Petitioners' Offers of Proof and Substantive Contentions Regarding the Project's Alleged Adverse Environmental Impacts on Community Character are Baseless and Do Not Raise an Adjudicable Issue

Even if community character could be adjudicated as a separate issue (which it cannot), petitioners' offers of proof and substantive contentions regarding the Project's alleged adverse environmental impacts on community character are comprised of baseless and non-empirical speculation that do not raise an adjudicable issue.

It has been repeatedly held that "a potential party's assertions cannot be simply conclusory or speculative but must have a factual or scientific foundation." *Entergy Nuclear*

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[2] One petitioner – Finger Lakes Wine Business Coalition – cites to some superseded decisions to argue that community character can be adjudicated as a separate issue. Finger Lakes Wine Business Coalition petition at 15. However, one of the decisions cited by petitioner – *Lane Construction Co.*, 1998 WL 389019 (NYSDEC 1998) – does not even mention "community character." To the extent the other decisions cited by petitioner – *Palumbo Block Co.*, Interim Decision, 2001 WL 651613 (NYSDEC 2001) and *WHIBCO, Inc.*, 1998 WL 389014 (NYSDEC 1998) – can be read to support community character as a separately adjudicable issue, those decisions have been superseded by the cases cited by Finger Lakes LPG Storage and no longer represent good law on that point.

[3] *See* DSEIS §§ 4.3, 4.4, 4.5, and 4.6.

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Indian Point 2, LLC and Energy Nuclear Indian Point, LLC, Interim Decision of the Assistant Commissioner, 2008 WL 4693295, *31 (NYSDEC 2008); *Buffalo Crushed Stone, Inc.*, Decision of the Commissioner, 2008 WL 5955358, *4 (NYSDEC 2008) ("conclusory or speculative statements without a factual foundation are not sufficient to raise an adjudicable issue"). "Conducting an adjudicatory hearing 'where offers of proof, at best, raise [potential] uncertainties' or where such a hearing 'would dissolve into an academic debate' is not the intent of the Department's hearing process." *Id.* As discussed below, Petitioners' community character arguments violate this rule.

Two of the three petitions alleging community character impacts rely primarily on the "Community Character Analysis" prepared by Harvey K. Flad ("Flad Memo"), which was submitted as Exhibit 5 to the Gas Free Seneca petition.[4] The Flad Memo is 39 pages long but less than three pages actually discuss the Project's purported environmental impacts on community character.[5] In those three pages, the Flad Memo asserts that the Project will impact community character in three ways: visual impacts, traffic impacts, and noise impacts. But Dr. Flad is a geographer with no discernible expertise or experience in assessing visual, traffic, or noise impacts, which is apparent from the text of the Flad Memo itself. The Flad Memo's cursory treatment of the Project's alleged visual, noise, and traffic impacts consists entirely of unsubstantiated and conclusory opinions without any technical basis or analysis whatsoever; and the Flad Memo makes no attempt to employ the techniques established in the Department's guidance documents for assessing visual or noise impacts. For example, instead of employing the empirical methodologies prescribed in the Department's written policy entitled "Assessing

[4] The Flad Memo is also cited in the community character section of the Seneca Lake Communities' petition (at 8).
[5] Flad Memo at 34-36.

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and Mitigating Visual Impacts," the analysis is comprised of subjective and nebulous assertions that are impossible to confirm or verify:

> The visual impact of a facility is less a matter of seeing something as it is, but more a matter of understanding what is seen. The environmental impact of a proposed industrial facility and its infrastructure can be both measured within a specific viewscape and regarded as a subtle indicator of a change to the local or regional economy and sense of place.[6]

Contrary to these novel assertions, the Project's visual impacts are a function of what will actually be seen. A subjective "understanding" of a facility's existence apart from its actual viewshed is not a visual impact. These types of non-technical and quasi-psychological assessments of the Project's alleged environmental impacts – which serve as the basis for the overwhelming majority of the Flad Memo's conclusions, and in turn form the basis for the petitioners' community character arguments generally – fall woefully short of the offer of proof necessary to raise a substantive and significant issue. *See, e.g., Buffalo Crushed Stone, Inc.*, Decision of the Commissioner, 2008 WL 5955358, *6 (NYSDEC 2008) ("mere expressions" of "opinions without substantiation are insufficient to establish that an issue is substantive and significant").

As evidenced by the Flad Memo, petitioners' contentions regarding the Project's alleged community character impacts are to a remarkable extent not based on generally accepted and scientifically quantifiable methods to assess environmental impacts. Instead, petitioners repeatedly argue that the Project will damage community character based merely on the psychological "perception" that "industrialization" is taking place:

> the potential for diminished tourism as a result of a *perception* that the region has become industrialized and contains hazardous activities potentially affecting public health. In turn, a reduction in tourist activity will cause impacts such as the closing of businesses and decline in

[6] Flad Memo at 34.

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> agricultural output, both leading to increased vacancy rates among commercial properties.[7]

All three petitioners commenting on the Project's community character impacts use "perception" as a shorthand for the assertion that the Project's impacts will be greater than those that can be objectively measured.[8] This illusory and ineffable effect – wholly divorced from any empirical mechanism of impact – is repeatedly invoked in the Flad Memo:

> …the Project will overlay an indelible industrial image on the cultural landscape of Seneca Lake, and the Finger Lakes more broadly, which will significantly and adversely affect the inhabitants' hard-won and prized community character.[9]

Not only are these scenarios fantastically speculative (neither Dr. Flad nor any of the petitioners offer any rational explanation how the Project's modest and manageable visual, noise, traffic, or other environmental impacts could result in such profound impacts on the region's entire "cultural landscape") but they are also based on hypothetical adverse emotional reactions to the mere knowledge that the Project exists, as opposed to a quantifiable assessment of the Project's actual environmental impacts. Under SEQRA, however, such "psychological impacts are not recognized as environmental impacts." *Oneida-Herkimer Solid Waste Mgmt. Auth.*, Rulings of the ALJ on Party Status and Issues, 2001 WL 112141, *47 (NYSDEC 2001); *see also, e.g., Industrial Liaison Committee of the Niagara Falls Area Chamber of Commerce v. Williams*, 72 N.Y.2d 137, 143 (1988) (SEQRA agencies may "ignore speculative environmental consequences").

One petitioner also contends that the DSEIS is inadequate because it fails to evaluate environmental impacts of "the risks of events associated with rail transport [and] pipeline

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7 Finger Lakes Wine Business Coalition petition at 14 (emphasis supplied).

8 *See* Gas Free Seneca petition at 17; Finger Lakes Wine Business Coalition petition at 14; Seneca Lake Communities at 9, 12.

9 Flad Memo at 39.

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transmission."[10] However, because SEQRA does not alter the agencies' jurisdiction (ECL § 8-0103(6)), it has repeatedly been held that federal law preempts state environmental review under SEQRA of actions or subjects subject to exclusive federal jurisdiction. *E.g., Erie Boulevard Hydropower, L.P. v. Stuyvesant Falls Hydro Corp.*, 30 A.D.3d 641, 645 (3d Dep't 2006) (citing numerous cases for this proposition). It has specifically been held that "environmental review of [a] pipeline under SEQRA was preempted by the regulatory authority of the Federal Energy Regulatory Commission." *East End Property Co. No. 1, LLC v. Kessel*, 46 A.D.3d 817, 823 (2d Dep't 2007); *see Skyview Acres Co-op, Inc. v. Public Service Com'n*, 163 A.D.2d 600, 602 (2d Dep't 1990) ("It is well settled that the regulation of interstate gas pipelines is a matter within the exclusive jurisdiction of the FERC. The Federal preemption of State regulations of such pipelines, however, extends to State assessment of environmental matters."). Similarly, federal law vests the Surface Transportation Board with exclusive jurisdiction over "transportation by rail carriers" including, among other things, the "operation" of railroad tracks, which preempts any state or local permitting requirements, including "environmental requirements." *Green Mountain R.R. Corp. v. Vermont*, 404 F.3d 638, 642 (2d Cir. 2005) (citing 49 U.S.C. § 10501). Because review under SEQRA of the environmental impacts of rail transport and pipeline transmission is preempted by federal law, petitioner's argument that the DSEIS for the Project was required to review "the risk of events associated with rail transport [and] pipeline transmission" is erroneous, and those topics cannot be substantive and significant issues as a matter of law.

Petitioners' community character arguments are conclusory, speculative, remarkably devoid of factual or scientific foundation, incorrect as a matter of law, and thus fail to raise an

[10] Gas Free Seneca petition at 10, 12.

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adjudicable issue. *See Entergy Nuclear Indian Point 2*, 2008 WL 4693295 at *31; *Buffalo Crushed Stone*, 2008 WL 5955358 at *4.

C. Petitioners' Assertions Regarding the Project's Economic Impacts Are Factually Incorrect and Not Cognizable Under SEQRA and Thus Do Not Constitute a Substantive and Significant Issue

As part of their community character arguments, petitioners assert that the Project will have negative economic impacts – primarily on regional wine tourism. Petitioners' arguments are factually incorrect and not legally cognizable as an adjudicable issue under SEQRA.

As detailed in the report entitled "Economic and Fiscal Impact of the Finger Lakes LPG Storage Project" prepared by the economists at Camoin Associates ("Camoin Report"), "the net economic impact of the Project is expected to be positive:"

> Overall, the Project will have a *one-time* economic impact to Schuyler County of 58 jobs, $2.3 million in earnings, and $5.6 million in economic output. Additionally it will generate an *annual* economic impact of 17 jobs, $684,000 in earnings, and $507,000 in indirect economic output in the County. The net fiscal impact of the Project (i.e. municipal revenues less expenditures related to the Project) will be $613,000 annually.[11]

After noting the decades-long existence of similar LPG and natural gas storage activities in the area of the Project, and then empirically evaluating the Project's actual environmental impacts that have been assessed by other experts pursuant to accepted methodologies,[12] the Camoin Report concludes as follows with respect to the Project's impact on regional tourism:

> Tourism has not appeared to be adversely impacted by the existing LPG and natural gas storage activities that have occurred or are occurring in and around the Project Site. Furthermore, as outlined previously in this analysis, there appear to be no visual, noise, traffic, smell, health or other adverse conditions related to the Project that might potentially impact

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[11] Camoin Report at ES-1.

[12] Camoin Report at 4-15 (summarizing and fiscally analyzing the Project's potential visual, noise, traffic, catastrophic event, olfactory, health, construction spending, and operational spending impacts as assessed by other experts). The methodology of the Camoin Report – which bases its economic analysis on actual environmental impacts that have been assessed by other experts pursuant to accepted methodologies – stands in stark contrast to the Flad and Christopherson Memos, which lack any factual or scientific basis or methodology. In addition, the Camoin Report is being submitted to demonstrate the failure of and refute petitioners' offer of proof on the *substance* of the economic matters they proffer. Finger Lakes LPG Storage's affirmative position is that the community character, economic, and like contentions of petitioners do not raise adjudicable issues.

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> tourism. We can find no basis to expect a meaningful impact on tourism. We note that propane is used in the winery industry for heating fuel, crop drying and other purposes. To the extent that local propane storage has helped lower costs in Schuyler County, the local wineries using propane have benefitted from the cost savings.[13]

Petitioners' factual assertions regarding the Project's alleged adverse economic impacts on community character and regional tourism are primary based on the Flad Memo and the accompanying whitepaper by Susan Christopherson entitled "Sources of Economic Development in the Finger Lakes Region: The Critical Importance of Tourism and Perceptions of Place," which was attached as Exhibit 6 to the Gas Free Seneca petition ("Christopherson Memo"). Dr. Flad is not an economist, however, and his discussion of economic impacts is comprised of superficial opinions with no foundation in economic methodology. While the Christopherson Memo asserts that the Project will have an adverse impact "on the region's economic success," that contention is stated in an entirely conclusory and unsubstantiated fashion with no explanation of how or why the Project's actual environmental impacts could negatively impact the regional economy.[14] Petitioners' assertions regarding the negative impact of industrial activity on the regional economy/community character are also belied by the text of the Christopherson Memo itself, which recognizes (correctly) that industrial activities of numerous kinds – including energy storage activities identical to the Project – are part of the existing and historic economic character of the region:

> Though it still exists in some places in the region, heavy industry is less and less part of the vision of the region's future. The proposed butane and propane storage at the Reading site is at odds with the direction of the contemporary regional economy and potentially threatens its continued successful development. The creeping industrialization up the west side of Seneca Lake – from salt manufacturing, to natural gas storage, and potentially LPG storage – endangers the hard-fought-for brand (for world-

[13] Camoin Report at 21.
[14] Christopherson Memo at 11.

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> class wines in a world-class natural environment) that is central to the region's economic future.[15]

While the Christopherson Memo asserts that industrial activity is "less and less part of the vision of the region's future," industrial activity accounts for approximately 13.5% of employment in Schuyler County,[16] which is greater than the 12.4% of county employment attributable to tourism cited by one petitioner.[17]

Petitioners' erroneous claims regarding the disappearance of industrial activity in the region are also belied by the Schuyler County Countywide Comprehensive Plan ("SCCCP"), which was adopted less than a year ago in May 2014 and is described as the "blueprint" for the community.[18] According to the SCCCP, manufacturing accounts for 46% of all jobs in the Town of Reading (where the Project would be located) and is defined as the "primary employment industry" in the town.[19] The SCCCP further notes:

> The natural resources of Reading help make the Town economically successful. US Salt, the Town's largest employer and an *important* source of manufacturing in the region, is located within Reading on the Watkins Glen border.[20]

The existence of a robust manufacturing industry in Reading and the resulting high-paying jobs are critical elements of the community's character that have resulted in the town having one of the strongest economies in the region:

> The economic climate of the Town of Reading is one of the best in Schuyler County. Reading has the highest median household income ($58,583) of all towns in the County, the lowest unemployment rate (3.1%), and second lowest poverty rate (4.2%).[21]

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15 Christopherson Memo at 4.
16 *See* New York State Department of Labor data at http://labor.ny.gov/stats/cesminor.asp for Schuyler County, New York (using current month's data)
17 Finger Lakes Wine Business Coalition petition at 18.
18 SCCCP at 2. The SCCCP is available at: http://www.schuylercounty.us/DocumentCenter/View/2215.
19 SCCCP at 29, 70.
20 SCCCP at 68 (emphasis added).
21 SCCCP at 68.

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The SCCCP also shows that the Project would be located in a section of Reading where the existing land use pattern is "industrial."[22]

Despite the historical and continued existence of industrial activity in the Finger Lakes region, petitioners essentially argue that because (in their view) industry is inconsistent with their Rhone Valley-like "vision" of "pastoral landscapes dominated by vineyards and wineries," no industrial activity of any kind should be permitted in the region.[23] Such a policy would be extremely damaging to the regional economy and employment and could theoretically only be established by the elected branches of government, including through zoning under the well-established procedures of New York statutory and common law and due process through the court system. Moreover, notwithstanding the growth of the wine tourism industry in the Finger Lakes, total tourism accounts for only 6.3 percent of regional employment.[24] While viticulture and related tourism may be a part of the regional economy, the progress of those industries does not empower their proponents to exclude other types of businesses they disfavor through amorphous contentions, especially via a state-driven process such as the instant proceeding which is not constructed for such an endeavor.

Moreover – and once again – petitioners' arguments regarding the Project's allegedly negative economic impacts on community character and regional tourism are not adjudicable under SEQRA. It is well established that because economic impacts are "beyond the scope of SEQRA" (*Sun Co., Inc. v. City of Syracuse Industrial Development Agency*, 209 A.D.2d 34, 50 (4th Dep't 1995)), "purely economic impacts are not adjudicable," including as part of community character. *St. Lawrence Cement Co. LLC*, Initial Rulings of the ALJs on Party Status

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22 SCCCP at A-8.
23 Finger Lakes Wine Business Coalition petition at 18.
24 *Id.*

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and Issues, 2001 WL 1587361, *109 (NYSDEC 2001). The Commissioner's ruling in *St. Lawrence Cement* is instructive:

> Moreover, to the extent that [the petitioner] seeks to raise various other economics-related matters as an element of community character, such as the project's potential impact on the property market for historic structures, on local property values, and on certain economic sectors (tourism, second home ownership and antique businesses), these matters fail to present an adjudicable issue. Reduction of property values and other economic-related matters standing alone are not considered to be environmental impacts.

2004 WL 2026420, *51 (citing *Hyland Facility Assoc.*, Interim Decision, 1992 WL 290000, *4 (NYSDEC 1991) (potential loss or revenue derived from tourism not a community character issue, but an economic consideration which was not adjudicable)).

Accordingly, Petitioners' assertions regarding the Project's negative economic impacts on community character and regional tourism are not adjudicable.

D. Analysis of the Project's Impacts on Community Character Was Not Required Under the Final Scoping Outline

As discussed in more detail in the Alternatives section, *infra*, the purpose of the Final Scoping Outline for the DSEIS issued by the Department on February 15, 2011, was to "focus the EIS on potentially significant adverse impacts and to eliminate consideration of those impacts that are irrelevant or nonsignificant." 6 NYCRR § 617.8(a). Finger Lakes LPG Storage was not required to incorporate analysis of issues into the DSEIS that were not included in the final written scope. 6 NYCRR § 617.8(h). The Final Scoping Outline for the DSEIS does not mention the phrase "community character" or require that an evaluation of the Project's community character impacts be included in the DSEIS; and the SEQRA regulations do not require the DSEIS to evaluate the Project's alleged impacts on community character. 6 NYCRR § 617.9(b)(5). Accordingly, the DSEIS was not required to include an evaluation of the Project's alleged community character impacts.

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IV. Petitioners' Objections to the Indemnification Provisions of Draft Permit Condition 9 Cannot be Adjudicated Under SEQRA

Some petitioners object to the indemnification provisions of Draft Permit Condition 9 because they assert the indemnification language does not offer adequate economic protection, is unclear as to the scope of Finger Lakes LPG Storage's economic responsibilities, and there has not been adequate assessment of Finger Lakes LPG Storage's ability "to meet its financial responsibilities under Draft Permit Condition 9."[25] None of these objections to Draft Permit Condition 9 can be adjudicated under SEQRA, and petitioners have not identified any other statutory or regulatory criteria that that the condition allegedly violates. *See* 6 NYCRR § 624.4(c)(2).

As previously noted, economic impacts are "beyond the scope of SEQRA" and "purely economic impacts are not adjudicable," *Sun Co.*, 209 A.D.2d at 50; *St. Lawrence Cement*, 2001 WL 1587361 at *109.

Here, Draft Permit Condition 9 reads as follows:

> The Permittee expressly accepts the full legal responsibility for all damages, direct or indirect, of whatever nature, and by whomever suffered, arising out of the storage facility's construction and operation to the extent such liability is attributable to the actions of the Permittee, its employees, agents, contractors or subcontractors, and to the extent the Permittee is liable under the law for such actions. The Permitee must indemnify and save harmless the State for suits, actions, damages, and costs of every nature and description resulting from such actions.

As an initial matter, we understand the indemnification provisions of Draft Permit Condition 9 are entirely consistent with the obligations imposed by the Department on operators of other underground hydrocarbon storage facilities in the state. More importantly, Petitioners' arguments regarding the adequacy of the economic protection afforded by Draft Permit Condition 9, and Finger Lakes LPG Storage's ability to meet its financial responsibilities under

[25] Seneca Lake Communities petition at 22-24; Finger Lakes Wine Business Coalition petition at 19-20.

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this permit condition, clearly relate to the hypothetical economic impacts of the Project in the unlikely event of damages being suffered by third-parties or the State of New York as a result of construction or operation of the Project. The presence of such a purely economic and non-environmental condition in the Draft Permit does not alter the fact that "purely economic impacts" like those addressed in the Condition 9 are "beyond the scope of SEQRA" and "cannot be adjudicated." Sun Co., 209 A.D.2d at 50; St. Lawrence Cement, 2001 WL 1587361 at *109. Because economic impacts cannot be adjudicated under SEQRA – and especially the theoretical economic impacts underlying petitioners' objections to the indemnification provisions of Draft Permit Condition 9 – petitioners' objections to that permit condition do not raise an adjudicable issue.

V. The Analysis of Alternatives in the DSEIS Complies with the Requirements of SEQRA

Some petitioners allege that the analysis of alternatives to the Project in the DSEIS does not satisfy SEQRA because (1) the DSEIS does not adequately evaluate the "no action" alternative, or (2) certain specified alternatives to the Project are not evaluated. These erroneous arguments ignore relevant provisions of the DSEIS and the Final Scoping Outline for the DSEIS issued by the Department on February 15, 2011. The analysis of Project alternatives in the DSEIS fully complies with the requirements of SEQRA.

A. The DSEIS Satisfies the Substantive Requirements of a No Action Discussion

Under 6 NYCRR § 617.9(b)(5)(v), all draft environmental impact statements must include a discussion of the "no action alternative." The "substance of the 'no action' discussion should be a description of the likely circumstances at the project site if the project does not proceed." *SEQRA Handbook* at 124 (3d ed. 2010); *see Wilmorite, Inc.*, Decision of the Commissioner, 1982 WL 177242, *22 (NYSDEC 1982) (defining "the 'no action' alternative" as

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"the continuation of the present land use utilization of the proposed Project Site"). Furthermore, "for many private actions, the no action alternative may be simply and adequately addressed by identifying the direct financial effects of not undertaking the action." *SEQRA Handbook* at 124; *see Gernatt Asphalt Products, Inc.*, Rulings of the ALJ on Party Status and Issues, 1994 WL 1735233, *17 (NYSDEC 1994). The DSEIS for the Project satisfies these requirements.

The DSEIS includes a "description of the likely circumstances" at the site of the Project if the Project "does not proceed." *See SEQRA Handbook* at 124. Nine separate sections of the DSEIS do exactly what a no action discussion requires by describing the existing environmental setting of the Project, which will remain the same if the Project does not proceed. *See* DSEIS §§ 4.1.1.1, 4.1.2.1, 4.1.3.1, 4.2.1.1, 4.2.2.1, 4.3.1, 4.4.1, 4.5.1, and 4.6.1.

Moreover, the DSEIS clearly identifies the "direct financial effects of not undertaking" the Project, which is an adequate method to satisfy the no action discussion for "many private action." *SEQRA Handbook* at 124; *Gernatt Asphalt*, 1994 WL 1735233, *17. As explained in the DSEIS, the long supply routes for the Northeast propane market create "imbalances where demand exceeds local available supply during peak periods;" such imbalances can be "extreme" during severe winters.[26] Regional supply imbalances can cause increases in retail prices to consumers between 20-35% which would increase the average price of a 400 gallon winter tank fill from $1000 to $1350" – and the percentage increase is exacerbated when fuel prices are lower.[27] The Project "will ultimately make available 2.1 million additional barrels or over 88 million gallons of local supply" that can be immediately available.[28] This additional supply will result in direct financial benefits to regional customers:

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[26] DSEIS § 3.3.1.
[27] *Id.*
[28] *Id.*

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> The need for the Finger Lakes project is that pipeline allocations and the need for large volumes of spot product at higher pricing spreads will be dramatically reduced relieving millions of dollars of potential burden from consumers and helping to ensure the use of clean burning fuels.[29]

The DSEIS then summarizes the economic benefits of the Project as follows:

> The total estimated project cost is $40 million. It is expected that approximately 50 construction jobs and 8-10 permanent full time jobs paying approximately $40-50,000/job will be created. In addition, the facility will result in indirect job creation, including jobs for railroad employees and trucking industry. Finger Lakes' operations in Schuyler County and the Town of Reading will also generate real property tax revenues for the County, Town and local school district.[30]

The DSEIS thus describes "the direct financial effects" of not undertaking the Project, which satisfies the requirement for a no action discussion under SEQRA. *See SEQRA Handbook* at 124; *Gernatt Asphalt*, 1994 WL 1735233, *17.

Moreover, as a supplemental EIS, the required analysis in the DSEIS is limited "to issues either not addressed or inadequately addressed" in the GEIS on the Oil, Gas and Solution Mining Regulatory Program. *SEQRA Handbook* at 6; 6 NYCRR § 617.10(d)(4). The GEIS incorporated Section XXI(A) of the DGEIS, which addressed the effect of prohibition of developing resources like those used in the Project. This no action discussion in the GEIS, coupled with the no action discussion in the DSEIS for the Project detailed above, satisfies the requirements under SEQRA.

Inasmuch as the DSEIS for the Project satisfies the substantive requirements for a no action discussion, petitioners' arguments are based merely on the fact that the DSEIS does not use the words "no action alternative." However, in assessing the sufficiency of environmental analysis, form cannot be elevated over substance. *E.g., Wyoming v. U.S. Dept. of Agriculture*, 661 F.3d 1209, 1263 (10th Cir. 2011); *Metcalf v. Daley*, 214 F.3d 1135, 1142 (9th Cir. 2000); *see Town of Henrietta v. Dept. of Environmental Conservation*, 76 A.D.2d 215, 220 (4th Dep't

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[29] *Id.*
[30] DEIS § 3.3.5.

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1980) (citing federal NEPA precedent in interpreting the substantive requirements for an EIS under SEQRA). Because the DSEIS satisfies the substantive requirements for a no action discussion described above, the DSEIS complies with the requirements of Section 617.9(b)(5)(v) even when the words "no action alternative" are not expressly invoked.

B. The Analysis of Alternatives in the DSEIS Complies with the Requirements of the Final Scoping Outline

Some petitioners argue that the DSEIS is inadequate because it does not evaluate a variety of Project alternatives proposed in the petitions for party status. However, the alternatives to the Project to be evaluated in the DSEIS were defined in the Final Scoping Outline, and the DSEIS properly addresses each of those alternatives. Contrary to petitioners' arguments, the DSEIS is not required to evaluate any alternatives not included in the Final Scoping Outline. As a result, the analysis of alternatives to the Project in the DSEIS complies with SEQRA.

A Final Scoping Outline for the DSEIS was issued by the Department on February 15, 2011. The "purpose of scoping is to narrow issues." *SEQRA Handbook* at 102; *see* 6 NYCRR § 617.8(a). One of the objectives of scoping is to "define reasonable alternatives for avoiding specific impacts which must be included in the EIS, either as individual scenarios or a range of alternatives." *SEQRA Handbook* at 103. "There is a strong presumption that a final scope acts essentially as a 'contract' between the lead agency and the sponsor, to give both certainty and reliance as to expectations for the actual EIS that is to be produced." *Id.* at 103. If an issue is raised after issuance of the final written scope, and the entity raising the issue provides a written statement explaining why the issue was not raised during scoping and why it should nevertheless be evaluated, the project sponsor may incorporate the late-raised issue in the DEIS "at its discretion." 6 NYCRR § 617.8(g, h); *SEQRA Handbook* at 109.

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The Final Scoping Outline defined three alternatives to the Project to be evaluated: (1) alternative sites in the "general project area" owned by, or under option to, Finger Lakes LPG Storage; (2) alternatives sizes of the Project, specifically including comparisons of one or two brine ponds; and (3) alternative access using a neighboring property, with an existing permitted driveway, to access the Project facilities. The DSEIS addresses each of these alternatives. With respect to (1) alternative sites and (3) alternative access using a neighboring property, the DSEIS states:

> Given that the solution mining wells already exist, Finger Lakes did not consider other greenfields in the vicinity of the site for an underground storage LPG facility. In addition, given the use of the US Salt property for solution salt mining, underground natural gas storage, and with this application, LPG storage, it was not feasible to locate the surface facility on the US Salt property. Therefore, Finger Lakes acquired property on NYS Route 14A because it is contiguous to property US Salt owns on the west side of NYS Route 14 making the pipeline connection possible without having to acquire any easements from other property owners.[31]

With respect to alternative sizes for the Project, the DSEIS evaluates five alternative Project designs, including: two ponds in the current location; two ponds aligned in an alternative north/south orientation; a single pond located on the property purchased for rail siding; a single pond north of the cemetery; and a single or double pond layout on the US Salt property. Thus, in compliance with the requirements of SEQRA, the DSEIS evaluated the range of reasonable alternatives defined in the Final Scoping Outline.

Some petitioners argue that the DSEIS was required to analyze a range of alternatives to the Project that are not included in the Final Scoping Outline. For example, notwithstanding that the Final Scoping Outline limited alternative sites to be evaluated to those controlled by Finger Lakes LPG Storage in the "general project area," some petitioners argue that the DSEIS should have evaluated a litany of alternative sites, including sites in New Jersey, Pennsylvania, and

[31] DSEIS § 5.0.

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every state in New England.[32] The assertion that the DSEIS must evaluate alternative sites for the Project in other states also ignores the rule that the DSEIS must only consider "reasonable alternatives" that are consistent with the "objectives and capabilities of the project sponsor" (6 NYCRR § 617.9(b)(5)(v)); the objective of the Project is using existing caverns as storage to benefit New York consumers could not be achieved by moving the Project to other states.[33] Another petitioner argues that the DSEIS is inadequate because it does not analyze an alternative Project design eliminating truck deliveries; again, however, the Final Scoping Outline did not require that the DSEIS evaluate such an alternative.[34] None of the petitioners arguing that these alternative Project designs should have been evaluated in the DSEIS raised these issues during the scoping process (or even after issuance of the Final Scoping Outline pursuant to 6 NYCRR § 617.8(g)). As a result, Finger Lakes LPG Storage was not required to include evaluation of any of these late-raised alternatives to the Project in the DSEIS. 6 NYCRR § 617.8(h).

One petitioner also argues that a further supplement to the DSEIS for the Project must be prepared because Finger Lakes LPG Storage recently submitted a revised Product Transportation Allocation indicating that truck deliveries of LPG may be reduced based on market forecasts, which (in petitioner's view) amounts to an unevaluated alternative to the Project.[35] Petitioner's erroneous argument ignores the controlling law on when a supplement to an EIS must be prepared, however. It is well established that a supplemental EIS may only be required when "specific significant adverse environmental impacts" are not addressed or inadequately addressed in an EIS that arise from changes proposed to a project, newly discovered information, or a change in circumstances related to the project. *Riverkeeper, Inc. v. Planning Bd. of Town of Southeast*, 9 N.Y.3d 219, 231 (2007) (citing 6 NYCRR § 617.9(a)(7)).

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[32] Seneca Lake Communities petition at 21-22.
[33] DSEIS §§ 2.1, 3.3.
[34] Gas Free Seneca petition at 21.
[35] Gas Free Seneca petition at 18-19, 21-22.

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Petitioner ignores this operative standard for requiring a supplement to the DSEIS for the Project and cannot explain how the submission of the revised Product Transportation Allocation will result in "specific significant adverse environmental impacts" that were not addressed or inadequately addressed in the DSEIS. *See Riverkeeper*, 9 N.Y.3d at 231. Because petitioner has not identified any "specific significant adverse environmental impacts" resulting from the revised Product Transportation Allocation, no supplementation of the DSEIS is required.

VI. The DSEIS Was Not Required to Analyze the Project's Purported Cumulative Impacts

One petitioner argues that the DSEIS does not comply with SEQRA because it does not evaluate the Project's "potential cumulative impacts" in conjunction with the impacts of the nearby Arlington Storage Company natural gas storage project ("Arlington Facility").[36] Petitioner's argument is legally erroneous in multiple respects and must be rejected.

A. Petitioner Has Not Alleged – and Cannot Show – that the Environmental Impacts of the Project and the Arlington Facility Will Accumulate to Have a Significant Effect on a Common Resource

"Cumulative impacts occur when multiple actions affect the same resource(s)." *SEQRA Handbook* at 81; *see also, e.g., Kathleen Wilson*, Decision of the Acting Commissioner, 2010 WL 5612181, *3 (NYSDEC 2010) (finding cumulative impacts because projects "would impair the natural resources of the river corridor"). A cumulative impacts assessment is only necessary when multiple actions will "take place simultaneously or sequentially in a way that the combined impacts may be significant." *Id.*; *see Crossroads Ventures*, 2006 WL 3873403, *29-30 ("when analyzing cumulative impacts under SEQRA, some nexus should exist between the matters to be considered together, and the combined impact must have the potential for a significant

[36] Gas Free Seneca petition at 19-20.

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environmental impact"). "[A]ssessment of cumulative impacts should be limited to consideration of probable impacts, not speculative ones." *SEQRA Handbook* at 81.

Here, petitioner has not even alleged –much less shown – that the environmental impacts of the Project and the potential Arlington Facility will affect any identified common resource. Nor does petitioner offer any basis for concluding that the impacts of the Project and the Arlington Facility on a common resource will accumulate to a level where, when combined, the effects on that resource will be significant. Petitioner does not even attempt to satisfy this standard, which is a prerequisite to mandating a cumulative impact analysis in the DSEIS for the Project.

B. <u>The Final Scoping Outline Did Not Require the DSEIS for the Project Include a Cumulative Impacts Assessment</u>

One petitioner states that an "EIS must discuss the 'reasonably related short-term and long-term impacts, *cumulative impacts* and other associated environmental impacts.'"[37] Petitioner misstates the cited regulation. Section 617.9(b)(5)(iii)([a]) does not state that an EIS "must" discuss cumulative impacts; rather, the regulation states that a "draft EIS should identify and discuss" cumulative impacts "*only* where applicable and significant." (Emphasis supplied). Petitioner has provided no basis to conclude that Project will have any significant cumulative impacts (as discussed above), and the Final Scoping Outline for the Project further established the inapplicability of a cumulative impacts analysis to the Project.

As previously noted, the purpose of the Final Scoping Outline for the DSEIS issued by the Department on February 15, 2011, was to "focus the EIS on potentially significant adverse impacts and to eliminate consideration of those impacts that are irrelevant or nonsignificant." 6 NYCRR § 617.8(a). Finger Lakes LPG Storage was not required to incorporate analysis of

[37] Gas Free Seneca petition at 19 (citing 6 NYCRR § 617.9(b)(5)(iii)([a]).

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issues into the DSEIS that were not included in the Final Scoping Outline. 6 NYCRR § 617.8(h). The Final Scoping Outline for the DSEIS does not mention "cumulative impacts," and (as noted) analysis of cumulative impacts is not mandatory under SEQRA. 6 NYCRR § 617.9(b)(5)(iii)([a]) (an EIS should identify and discuss cumulative impacts "only where applicable and significant"). And petitioner never raised this cumulative impact issue during the scoping process (or even thereafter prior to filing its petition for party status). Accordingly, no cumulative impacts exist relative to the Project and, in all events, the DSEIS was not required to include an evaluation of the Project's alleged cumulative impacts.

VII. The Reports Submitted by the Applicant, Along with the Voluminous Application Documents Demonstrate that there are No Adjudicable Issues

Geology/Cavern Integrity/Seneca Lake Water Quality

ECL § 23-1301(1) provides:

> No underground reservoir shall be devoted to the storage of gas, or liquefied petroleum gas unless the prospective operator of such storage reservoir shall have received from the department, after approval in writing of the state geologist, an underground storage permit which shall be in full force. The application for said permit shall include the following:
>
> a. A map showing the location and boundaries of the proposed underground storage reservoir.
>
> b. A report containing sufficient data to show that the reservoir is adaptable for the storage purposes.

DEC never promulgated detailed regulations regarding underground storage, but the subject was significantly reviewed as part of the Department's 1992 Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program ("GEIS"). It is clear, based on the expert reports that are part of the Application and provided herein, along with the issuance of the DEC draft permit and State Geologist approval, that the Applicant has provided sufficient data to show that its proposed galleries are suitable for storage purposes.

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In his report, Dr. Gowan, who has significant experience in salt geological formations, focused on assessing the potential for failure of the storage facility by product leakage from the wells, leakage through the geologic strata surrounding the caverns, catastrophic failure of the caverns and well bores from cavern collapse, the leakage or failure of the barrier pillars between the Finger Lakes LPG Storage galleries and neighboring galleries that are not part of the proposed Project. After conducting an independent review of all documents submitted by the Applicant, Dr. Gowan concluded that LPG can be stored successfully and safety at Finger Lakes LPG Storage Gallery 1 and 2.

In order that the issues conference serve a worthwhile function, it is not meant to merely catalogue areas of dispute, but rather make qualitative judgments as to the strength of the offers of proof and related arguments. With respect to the offer of proof, any assertions that a potential party makes must have a factual or scientific foundation. Speculation, expressions of concern, general criticisms, or conclusory statements are insufficient to raise an adjudicable issue. See, e.g., *Southwest Brooklyn Marine Transfer Station*, at 6; *Matter of Crossroads Ventures, LLC*, Interim Decision of the Deputy Commissioner, December 29, 2006, at 6; *Matter of Mirant Bowline, LLC*, Interim Decision of the Commissioner, June 20, 2001, at 3; *Matter of Bonded Concrete, Inc.,* Interim Decision of the Commissioner, June 4, 1990, at 2; *Matter of Seneca Meadows, Inc.*, Interim Decision, October 26, 2012, at 4.

In his report, Dr. Gowan demonstrates that the conclusions of Dr. Clark, Nieto, Vaughan and Myers are often without basis in fact or science and are unsupported by the significant testing of the proposed storage caverns that has been conducted. Moreover, he demonstrates that the Petitioners' purported experts have limited knowledge of how such storage caverns will operate.

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More specifically, with regard to Dr. Clark, Dr. Gowan concludes that Dr. Clark did not raise any questions or provide any new information about the solution-mined caverns and their future integrity that warrant identifying an issue for adjudication. Furthermore, Dr. Clark did not identify any data deficiencies within the Applicant's documentation that cast doubt that the permit should be issued. It is Dr. Gowan's conclusion that the geologic information, well integrity assessments, cavern integrity assessments and FEA provided by Finger Lakes LPG Storage for the proposed project along with the operational and monitoring guidelines in the draft NYSDEC permit and the successful current and past use for storage and the associated tests of the neighboring caverns all document the suitability of the proposed galleries for LPG storage.

The primary focus of Dr. Nieto's report was to provide a new interpretation of a fault purportedly connecting the storage field to Seneca Lake and to offer his additional theory of the existence of faulting/fracturing related to stress relief associated with the Seneca Lake valley. It is Dr. Gowan's conclusion that the fault interpreted by Dr. Nieto is not supported by data, is not realistic, and is contrary to the extensive data analysis and interpretation of Jacoby and Dellwig, whom Dr. Nieto has claimed the Applicant has ignored. It is Dr. Gowan's conclusion that Dr. Nieto's fault theory should be dismissed. It is also Dr. Gowan's conclusion that there is no data supporting Dr. Nieto's theory of fracturing in the site area from valley stress relief.

It is apparent from his report that Dr. Vaughan's lacks direct experience with salt behavior. It is Dr. Gowan's conclusion that Dr. Vaughan did not provide any substantive theories or proof of his theories that warrant identifying an issue for adjudication. Furthermore, it is Dr. Gowan's conclusion that the additional investigative work recommended by Dr. Vaughan will not provide substantive information that is any more informative then that already provided by the Applicant.

Dr. Myers does not provide any new information, new theory, or proof of a new theory that warrants identifying an issue for adjudication. Dr. Myers offers a theory of the cause of salt contamination in Seneca Lake that is unfounded, unsupported and implausible and, by his own words, the data collection and analyses necessary to assess the theory will be too difficult. It is Dr. Gowan's opinion that Dr. Myers' concept for the contamination of the lake is not consistent with science. As an example of his critique of Dr. Myers, Dr. Gowan observes that Dr. Myers' "advection" theory is one of the most unfounded, unsupported and implausible theories of advection flow that he has reviewed in nearly 40 years of professional experience. Simply put, according to Dr. Gowan, "this is not science." If pressures in neighboring galleries have not been recorded as the result of strain induced by an operating gallery at the site, then it is not realistic to expect an induced pressure 20 miles away.

Dr. Siegel and John Istvan also reviewed the reports submitted by Dr. Nieto, Dr. Vaughan, Dr. Myers, and Dr. Halfman. Dr. Siegel (a renowned hydrogeologist) and Mr. Istvan (who has over 50 years working in underground storage facilities in salt formations throughout the world) debunk, highlight the irrelevance, and sometimes even highlight the incredulity of some of the assertions made by the Petitioners' so-called experts. As they demonstrate, in some cases, the assertions made by the Petitioners reflect their total lack of knowledge of salt formations, the local geology, basic tenets of physics, well drilling basics, and how a storage cavern is operated.

Mr. Istvan's main conclusions include:

- The Petitioners have not demonstrated that there is a direct fault connection with the valley below Seneca Lake that would cause a path for hydrocarbons or brine to migrate out of the storage caverns since the lack of porosity and permeability of the confining salt, depth to the caverns and the low storage operating pressures will prevent that from happening.

- Petitioners have not demonstrated that faulting within the salt shows a possible route to the surface or Seneca Lake from the storage caverns.

- Known faulting within the salt has not been shown to provide exit paths for hydrocarbon leakage out of the caverns or to the surface, based on lack of porosity and permeability and sealing qualities of the plastic salt.

- The prior successful operation of Arlington Gallery 1 and new permitting of their Gallery 2 for natural gas storage have included all of the same questions being asked by Petitioners, and answers have been provided by the geologists reviewing Arlington's application for the Federal Energy Regulatory Commission.

Dr. Siegel observes that the fanciful notion that somehow there was and perhaps can be a connection between these caverns and high chloride levels in the Lake borders on the irresponsible. As Dr. Siegel notes:

- At no time historically have chloride concentrations in Seneca Lake approached NYSDEC or any other drinking water standards.

- Why Seneca Lake salinity in the past varied, in fact, has no scientific bearing on whether plausible problems at the proposed LPG facility will lead to additional salinization of the lake.

- Dr. Myers' claims that over-pressuring at the storage facilities could propagate a pressure wave 20 miles to the north and deform lake clays 50 meters thick to "squeeze" brine in the lake sediment to seriously contaminate the lake with chloride is "utterly beyond" Dr. Siegel.

- Dr. Siegel explains that, even when brine or propane are briefly over-pressured to allow them to replace and "push out" the fluid in the cavern, it is impossible that this tiny pressure pulse could, undissipated tens of miles to the north squeezed over a hundred feet of varved lake clay at the northern part of the lake, raise concentrations of chloride in the lake over a hundred milligrams per liter.

- Stating "possible", using false assumptions designed to "prove" points means little in science according to Dr. Siegel. Dr. Myers' notions are beyond implausible from first principles of physics. Dr. Siegel concludes that Dr. Myers' notions are simply contrived to meet desired ends.

- In conclusion, Dr. Siegel states that "the highly engineered LPG facility makes it neigh impossible for releases of salinity from the facility to Seneca Lake to increase salinity to above drinking water standards by any plausible cause."

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Based on the above and the entire record, the Applicant has rebutted any speculative claims of the petitioners for full party or amicus status. "Offers of proof submitted by a prospective intervenor may be completely rebutted by reference to any of the above, alone or in combination. In such a case, it would be a disservice to the applicant and the public at large to proceed any further with time-consuming and costly litigation." *In the Matter of New York State Thruway Authority,* Interim Decision Of The Commissioner*, April 25, 2002; Matter of Bonded Concrete*, Interim Decision of the Commissioner*, June 4, 1990, p. 2 (cited by Matter of Metro Recycling & Crushing, Inc.,* Decision of the Acting Commissioner*, April 21, 2005, p. 3).* Moreover, it is not sufficient to merely raise information counter to the position of an applicant. The offer of proof must be competent, not merely contrary." *In the Matter of New York State Thruway Authority,* Interim Decision Of The Commissioner*, April 25, 2002.* Dr. Gowan, Dr. Siegel and Mr. Istvan have clearly shown that the offers of proof made by the Petitioners are not competent or credible.

VIII. Safety

Petitioners (County Legislators, Finger Lakes Wine Business[38] Coalition, Seneca Lake Communities, and Gas Free Seneca) attempt to raise issues relating to risk, safety, rail safety and emergency response preparedness. However, the DSEIS and the record as a whole (including the documents submitted herein) demonstrate that Petitioners cannot satisfy their burden of persuasion that an issue exists for adjudication. Stated a different way, the DSEIS and the expert opinions and reports submitted by the Applicant and local emergency response personnel demonstrate that proper safeguards are in place to ensure that the facility will be operated safely,

[38] The County Legislators and the Finger Lakes Wine Business Coalition only seek Amicus Status.

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but if there is an event that requires emergency response, local officials and emergency personnel are well prepared to address any situation, including one relating to an unlikely release of LPG.

A. Risk Assessment

The Applicant is the only party who has submitted a credible and qualified Quantitative Risk Assessment. With the Quantitative Transportation Risk Analysis submitted herewith, risk analysis expert Quest Consultants has submitted two significant reports addressing the storage, handling and loading and unloading of LPG products (See Quantitative Risk Analysis for the Finger Lakes LPG Storage Facility, February 16, 2012; Document I.B.8) and risk (or lack thereof) associated with transportation of LPG. In both cases, Quest has concluded that the risk is well below accepted risk acceptance criteria.

With its Petition, County Legislators Harp and Lausell submit the report of D. Rob Mackenzie, MD. The report is also an attachment to Gas Free Seneca's petition. However, the qualifications of an expert witness that a petitioner identifies may also be subject to consideration at the Issues Conference stage. This particular threshold, one relating to qualifications, is most acute when it comes to the qualifications of a medical doctor performing a quantitative risk assessment for a facility such as that proposed by Finger Lakes LPG Storage. See, e.g., *Southwest Brooklyn Marine Transfer Station*, at 6; *Matter of Crossroads Ventures, LLC*, Interim Decision of the Deputy Commissioner, December 29, 2006, at 6; *Matter of Mirant Bowline, LLC*, Interim Decision of the Commissioner, June 20, 2001, at 3; *Matter of Bonded Concrete, Inc.,* Interim Decision of the Commissioner, June 4, 1990, at 2; *Matter of Seneca Meadows, Inc.*, Interim Decision, October 26, 2012, at 4.

Therefore, the Applicant objects to the introduction of any report by Dr. Mackenzie, who is not qualified to give any opinion about the risk profile of any aspect of this Project.

In its latest report, Quest nonetheless responds to Dr. Mackenzie's report, inappropriately designated as a quantitative risk analysis. Quest identifies numerous significant shortcomings of Dr. Mackenzie's risk assessment, and explains why Dr. Mackenzie's risk assessment *conclusions* are effectively an overprediction of the potential risk to the public in Schuyler County. The shortcomings in Dr. Mackenzie's analysis and lack of development of risk measures give an end result that has little to no value in determining the acceptability of the Finger Lakes LPG Storage facility. Therefore, Dr. Mackenzie's conclusions are not valid or credible as a means of determining the acceptability of the facility because it is biased, qualitative, and failed to provide any comparative assessment. His report, even if allowed to be introduced, certainly cannot form the basis of identifying a substantive and significant issue.

B. <u>Safety References in the DSEIS</u>

In addition to Quest's reports, the record is replete with references to the safety considerations the Applicant has identified and factored into its proposed operation. For example, the DSEIS identifies: (a) proposed mitigation measures, safety and emergency shutdown procedures (Section 4.1.3.3, pp. 83-84); (b) safety training it will undertake (Section 4.6.3, pp. 156, 160); (c) numerous safety related agencies that will have jurisdiction over the operation (Section 4.6.3, pp. 155-56); and (d) accidental release prevention and emergency response policies that will be in place (Section 4.6.3, p.157). Finger Lakes LPG Storage will also be required to implement a Risk Management Plan and Process Safety Management system pursuant to EPA and OSHA regulations. See DSEIS, Section 4.6.3, pp. 157-164.

C. <u>Emergency Preparedness</u>

The Applicant has demonstrated, through documents that are in the record (e.g., letters from Fire Chief Dominick Smith [Hearing Document I.B.6, attachment 17 and Finger Lakes LPG Storage engineer, Superior Energy Systems [Hearing Document I.B.6, attachment 14] that

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the facility will be safely designed, but if there is an incident local emergency response officials are trained and will be trained to respond.

To begin, the DSEIS addresses local emergency services and emergency preparedness in Section 4.6.1, pp. 144-147 (identifying local emergency resources), and Section 4.6.5, pp. 166-169 (discussing the capabilities of first responders). A written emergency response plan to deal with accidental releases of LPG will be in place. The plan will include all aspects of emergency response including adequate first aid and medical treatment, evacuations, notification of local emergency response agencies and the public, as well as post-incident decontamination of affected areas. Id.

In addition, William Kennedy, Schuyler County's Emergency Management Coordinator, has prepared an affidavit in which he concludes that Schuyler County government has adequately anticipated and addressed the risks of various activities throughout Schuyler County, including risks associated with the storage and transportation of LPG. According to Mr. Kennedy, these particular risks identified, analyzed and addressed by Schuyler County over several years, culminating with completion and implementation of the Schuyler County Hazard Mitigation Plan (May 2008) ("Hazard Mitigation Plan"). A multijurisdictional plan approved by the Federal Emergency Management Agency, the Hazard Mitigation Plan ranks (a) Hazardous Material Released in Transit, which would include the release of LPG as a result of a derailment or truck accident, as a Moderately High Priority Hazard, and (b) Hazardous Material Released from a Fixed Site, which would include the release of LPG from a pipeline or storage facility, as a Low Priority Hazard. Other Moderately High Priority Hazards ranking higher than Hazardous Material Released in Transit include severe storms, ice storms and terrorism, whereas only blight is ranked below Hazardous Material Released from a Fixed Site. A more detailed description of

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the scope of the LPG and natural gas transportation and storage activities occurring within Schuyler County is described in more detail in the draft "Appendix to the Hazardous Materials Plan – Transportation of Liquefied Petroleum Gas LPG" ("Draft Appendix") attached to the Petition of County Legislators Harp and Lausell. In sum, Mr. Kennedy concludes that, in his professional opinion, "the substance of the Draft Appendix (including the release modeling included therein) is more than adequate to coordinate preparedness activities and responses for incidents involving uncontrolled releases of LPG in transit or from stationary facilities."

The Plan referenced above that the Applicant has stated in the DSEIS it will prepare is now a requirement of the Draft Permit. Under the DEC Draft Permit:

> The Permittee must install and maintain appropriate safety and emergency shutdown devices at the storage facility. Prior to the injection of any LPG into any storage cavern subject to this permit, the Permittee must provide an electronic copy of its Operations, Maintenance and Contingency Plan to the Director of the Bureau of Oil & Gas Permitting and Management in the Albany office for its review and approval. The Operations, Maintenance and Contingency Plan must include, at a minimum, the Spill Prevention and Control Manual, Hazard Communication and Assessment Program, Safety Plan and Emergency Response Plan ("ERP"). The ERP must include, at a minimum, the following elements: (i) site name, facility type, location, map, and operator information, (ii) a chain of command including the identity and contact information of a knowledgeable and qualified individual or individuals with the authority to respond to emergency situations and implement the ERP, (iii) emergency notification and reporting procedures including a list of emergency contact numbers for the area in which the facility is located, (iv) identification, description and evaluation of potential LPG and/or brine releases, fire and explosion hazards, (v) description of fire and explosion prevention procedures and equipment, (vi) implementation plans for facility evacuation and shut down, as well as release containment and disposal, and a log to record any emergency events, (vii) relevant employee and site training, and (viii) security measures including signage, lighting and fencing. The Albany office and the Region 8 Avon Mineral Resources office must be on the call list included in the ERP for any well-or storage-related emergency. All updates to the ERP must be provided in electronic form to the Director of the Bureau of Oil & Gas Permitting and Management in the Albany office within 5 business days of implementing the update.

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DEC Draft Permit, November 10, 2014, Condition 7.

Given the above, there simply can be no doubt that, with the safety systems inherent in the design of the facility, the safety procedures that will be implemented as part of operations (and as required under Draft Permit Condition 7), and the attestations of the emergency response professionals whose job it is to respond to even unlikely events of an accident involving LPG, there is no issue for adjudication.

D. <u>Rail Safety</u>

Rail safety, including operational restrictions and maintenance requirements associated with rail bridges used in interstate commerce, is exclusively a matter of federal jurisdiction. The DEC, which has no particular expertise is rail safety, cannot identify an issue that is not properly the jurisdiction of federal agencies to regulate. As noted above, DEC decisions and New York case law reiterate the rule that "SEQRA does not alter the jurisdiction between or among state agencies". *See E.g., Green Mountain R.R. Corp. v. Vermont*, 404 F.3d 638, 642 (2d Cir. 2005) (citing 49 U.S.C. § 10501); *Erie Boulevard Hydropower, L.P. v. Stuyvesant Falls Hydro Corp.*, 30 A.D.3d 641, 645 (3d Dep't 2006) (citing numerous cases for this proposition); *Matter of Croton Watershed Clean Water Coalition Inc. v. Planning Bd. of Town of Southeast, 5 Misc. 3d 1010(A), 1010A (N.Y. Sup. Ct. 2004); Matter of William E. Dailey, Inc., Administrative Law Judge Rulings On Issues And Party Status And Order Of Adjudicatory Proceedings, April 5, 1995; Matter of CMW Industries, LLC, Administrative Law Judge Ruling On Issues, Party Status And Environmental Significance And Order Of Disposition, March 24, 2009.* This applies equally to federal agencies. Nevertheless, the DEC, or the relevant SEQRA agency, is allowed to rely on the expertise of other agencies to an extent that does not amount to delegation or deferral of responsibility. *Matter of Croton Watershed Clean Water Coalition Inc. v. Planning Bd. of*

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Town of Southeast, 5 Misc. 3d 1010(A), 1010A (N.Y. Sup. Ct. 2004) ("…merely relying on the expertise of other agencies which are involved in the SEQRA process, while fully retaining and exercising its role as lead agency in assessing environmental impacts, did not result in a delegation or deferral of responsibility").

The DSEIS contains numerous references to statistics compiled by Federal agencies that demonstrate the safety of commercial rail transport (including where LPG is transported). For example, there is no history over the last 10 years of rail accidents on the line to be utilized for the transport by Norfolk Southern of LPG to the Finger Lakes LPG Storage facility (DSEIS Section 4.6.2, p. 155). The DSEIS also identifies the manner in which rail operations will be conducted (Section 4.4.1.2, pp. 121-123) and the rail safety inspection program that is in place (in coordination with the Federal Railroad administration)(Section 4.4.3, pp, 128-129), including that track inspections are made weekly.

The rail industry has an excellent safety record. In part, this is due to the vigilance of the rail industry itself, but also because the rail industry is heavily regulated. As explained in Norfolk Southern's October 30, 2014 letter:

> Railroads and the transportation of hazardous materials are heavily regulated. The Surface Transportation Board has broad economic regulatory oversight of freight railroads, including service and construction requirements, and the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) regulates the transportation of hazardous materials. PHMSA regulations are designed to achieve three goals: (i) ensure that hazardous materials are packaged and handled safely and securely during transportation; (ii) provide effective communication to transportation workers and emergency responders of the hazards of the materials being transported; and (iii) minimize the consequences of an incident should one occur. PMHSA pursues these goals by establishing rules for classification, packaging, hazard communication, incident reporting, handling and transportation of hazardous materials.

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In the case of Norfolk Southern, PHMSA regulations require them to ensure its employees are appropriately trained to handle hazardous materials. See also DSEIS Section 4.4.3, pp. 129-130.

Indeed, as Norfolk Southern notes in its October 30, 2014 letter (attached), rail is an extremely safe way to transport hazardous materials. According to the Association of American Railroads, 99.9977% of all hazardous material rail shipments reach their destination without a release caused by a train accident. According to the Federal Railroad Administration, 1,782 railcars carrying hazardous materials were transported in New York between January 1, 2004 and December 31, 2013, with only 7 hazardous material releases from 12 railcars. During the same period, only three reportable rail accidents or incidents occurred within Schuyler County (includes railcars carrying hazardous materials and non-regulated freight), none of which resulted in a fatality or a release of hazardous materials. Norfolk Southern's local track record is particularly relevant considering (a) rail is the transportation lifeblood for many local, regional and national businesses located in New York, and (b) recent market changes are driving increased rail shipments of energy products in general and, in the case of the Northeast, greater volumes of propane are forecast to be transported to the Northeast to help satisfy winter demand.

In connection with risk and modes of transportation, Quest evaluated the risk profile for rail transportation and assessed the potential for an accident based on the statistics from federal agencies as referenced herein. Quest concluded that given that there had only been 40 release incidents of LPG materials from 2000-2012 nationwide representing nearly 2 billion track miles traveled, the risk due to LPG railway movements, assuming continuous public occupancy, is predicted to be approximately 2.0 x 10-7 per year (or one in 5,000,000 per year) on the railway, declining to **zero** at about 1,100 feet away from the rail line. See Quest Transportation QRA, pp. 29 and 49 (emphasis added). An LPG rail car derailment is equally unlikely according to Quest

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as it concluded that the potential amount to 2.73 x 10-8 per railcar-mile, or one chance of derailment in 36,630,000 per year per railcar. Quest Transportation QRA, p. 54. The actual statistics from year bear out the history for this decade. According to Norfolk Southern, it transported 531,582 carloads of hazardous materials last year (compared to roughly 350,000 carloads five years ago), while experiencing only three accidental releases involving six tank cars and non-accident releases involving 63 railcars. None of these releases involved LPG or occurred within New York, and the amount released in each case was relatively small. See Norfolk Southern October 30, 2014 letter.

Petitioners raise concerns about the Watkins Glen State Park gorge bridge, over which Norfolk Southern has operated without incident since 1999. The DSEIS explains (Section 4.4.3, pp. 130-131) that in 2010, the Federal Railroad Administration established federal safety requirements for railroad bridges, requiring track owners to implement bridge management programs, which include annual inspections of railroad bridges and to audit the programs (49 C.F.R. Part 237). The 303 feet of track that is part of the Watkins Glen State Park gorge trestle bridge is inspected at least twice a week and its structure is inspected annually. See also DSEIS Section 4.4.3, pp. 130-131. But again, it cannot be emphasized enough that the DEC has absolutely no regulatory authority to regulate activities involving the rail bridge, including rail traffic, operational restrictions and maintenance requirements associated therewith

IX. Noise

The noise report submitted by Earth Justice and prepared by Sandstone Environmental Associates ("Sandstone") is equally unavailing. According to the Applicant's expert, Hunt Engineers, the noise analysis it performed was appropriate, consistent with DEC's Noise Policy and industry standards. See Hunt Engineers memorandum dated February 9, 2015, attached. To the contrary, Sandstone's report ignored reality, made inappropriate leaps of faith about what can

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possibly be heard across the Lake, and failed to demonstrate that the noise that the Project will generate would not be out of character for its surrounding receptors.

The fundamental error in Sandstone's report relates to its suggestion that the Applicant's noise reports should have evaluated ambient sound across the Lake. However, this is contrary to the DEC Noise Policy in terms of what the appropriate receptor locations should be (as Hunt notes as well)--that is at the property line or at the location of the use or inhabitance on adjacent property. Assessing and Mitigation Noise Impacts, DEC Program Policy DEP-00-1, p. 13. While the Town of Reading does not have a local noise ordinance, the existence of such ordinances in the Town in which a project has been proposed has also been found to be relevant in previous DEC administrative decisions. See e.g., *Matter of St. Lawrence Cement Company,* First Interim Decision of the Commissioner, December 6, 2002*; Matter of Dalrymple Gravel & Contracting,* Ruling on Issues, September 25, 2001. This is indicative of the focus there has been in determining whether there is an issue for adjudication on noise on nearby receptors as being appropriate for evaluation in a noise study; not receptors nearly a mile away which could be influenced by many factors such as other uses not related to the operation of the storage facility. Finally, the Sandstone report failed to fully acknowledge or appreciate the noise monitoring condition included in the draft permit. For these reasons, no issue for adjudication has been identified.

X. <u>Conclusion</u>

To satisfy a petitioner's burden of proof, a petition for either full party or amicus status must identify an issue that satisfies the standards for adjudication under 6 NYCRR § 624.4(c). 6 NYCRR § 624.5(b)(2)(i), (b)(3)(i). Because the Petitioners requesting full party status and the Petitioners requesting amicus status have failed to identify any adjudicable issues with regards to the sufficiency of the DSEIS's analysis of the Project's community character impacts,

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alternatives, or cumulative impacts, the indemnification provisions of Draft Permit Condition 9, cavern integrity, water quality impacts, public safety and emergency preparedness, and noise, those petitions must be denied.[39]

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Dated: February 9, 2015

[39] Finger Lakes LPG Storage reserves the right to supplement, revise, or extend the information and arguments included and referenced in this document.

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Evaluating The Scientific Plausibility of "Salting" Seneca Lake By Storing Liquefied Propane in a Brine Filled Salt Mine, Watkins Glen, New York

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Introduction:

Of the Finger Lakes in upstate New York, Seneca and Cayuga Lake notably have higher salinity than others. Some have expressed concern that a proposed storage facility for liquefied petroleum gas (propane and butane) near Watkins Glen in a brine-filled salt solutioned mined cavern, 1,000 feet below the land surface, may lead to additional "salting" of Seneca Lake. Specifically, the concern is that additional "salting" could cause Seneca Lake to exceed New York State drinking water standards of 250 mg/L for chloride in particular, and to some extent sodium above 20 mg/L (http://www.dec.ny.gov/regs/4590.html), or otherwise cause environmental harm.

I review herein what scientists know and do not know about salinity in the Finger Lakes, and evaluate the *scientific* plausibility that operating a proposed liquefied petroleum gas facility near Seneca Lake can introduce enough salt into Seneca Lake to cause its water quality to exceed drinking water or other standards for salinity or chloride, or to cause environmental harm.

Salt in New York State

Salt has been a commodity in New York for hundreds of years. Thick rock salt, in what geologists call the "Salina Formation" (herein termed "the Salina") occurs throughout the southern half of western New York, at increasingly deeper depths below the land surface to the south. The salt formed in ancient shallow seas not only in New York, but over a large

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part of a crustal depression called the Appalachian Basin. The Salina, through geologic processes, is exposed at the land surface near where E-W trending I-90 occurs today. Here, the salt in the formation long dissolved away. However, to the south, thick salt remains in the subsurface.

Rock salt, be it in the subsurface or spread on roads, dissolves in water and increases the amounts (concentrations) of its constituents; chloride (Cl) and sodium (Na). Salt dissolves so efficiently and rapidly that the amount water can hold (called chemical "saturation") literally is almost ten times saltier than seawater. This highly salty water, called "brine", consists of about 30% dissolved salt by weight.

For over half a century, groundwater scientists have known that deep aquifers in New York State contain salt water (less than 10% salt) and brine (more than 10% salt) below a fresh zone less than 1000 feet deep (e.g. Feth et al. 1965). Some of the salt water below this fresh water zone comes from dissolving Salina salt, but also some salt water is fossil or "connate" water (e.g. Yager and Kappel, 2007), formed millions of year ago and which remains in the rocks today, often associated with natural gas. Scientists easily can determine whether salinity in water comes from dissolving rock salt or from original fossil water by looking at the proportions of chloride, sodium, and other dissolved chemicals in the water (e.g. Davis et al., 1998).

Salt water in upstate New York can even occur in salt springs, the end points of ground water flow paths originating on higher elevations, the ridges and hills. On hills and ridges, rain percolates into the ground to become ground water and flows underground dissolving salt or intersecting the fossil freshwater boundary.

This ground water moves finally upwards to topographic depressions often filled by lakes and streams. Brine springs notably flowed under artesian pressure to the shores of Onondaga Lake northeast of the Finger Lakes. The recharge (replenishment) areas for these springs are located on topographically higher regions south of Syracuse, New York. Since the 1700's, the brine flowing up at the Onondaga springs was harvested to provide

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table salt for the eastern United States. Syracuse salt even led to building the Erie Canal (Kurlansky, 2007.).

A commercial salt industry also developed along the southern shores of Cayuga and Seneca Lakes at the turn of the 20th century, expanding until the mid-1960's (Figure 1). There, both underground dry salt mines and hydraulically mined salt was used for table use and road salt. Dry salt mines are familiar to the public; deep underground excavations where the salt is mechanically cut out with large machines and brought to the surface for later processing.

Hydraulic mining consists of pumping fresh water through wells drilled into the deep salt, dissolving the salt to make liquid brine, and then pumping the brine to the surface for later evaporation to crystalize the salt. Underground cavities with volumes of equivalent to large buildings are created by both methods. Dry salt mines are filled with air and can collapse if engineering is not properly done. In contrast, hydraulically formed salt mine cavities are filled with brine, a non-compressible liquid, and so cannot collapse by definition.

Seneca Lake

Seneca Lake, the biggest of the Finger Lakes, has a maximum depth of 602 feet and a volume of 506 billion cubic feet of water (Bloomfield 1978). Put into context, this enormous volume, about 4 trillion gallons of water, would be sufficient to provide New York City its drinking water for eleven years.

Scientists have well documented the geologic history and water quality of Seneca Lake. Briefly, the lake formed by highly-pressurized water at the base of continental glaciers that crossed New York State north to south multiple times and tens of thousands of years ago. This pressurized water eroded the deep linear depression now filled by the lake (Mullins and Hinchey 1989; Mullins et al. 1996.). The erosion cut through thick rock layers; shale, siltstone and limestone, hundreds of feet deep. The glacial excavation also cut through the Salina salt in the northern part of the lake basin (Mullins et al, 1996).

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When the glaciers retreated, glacial melt water, glacial sediments, and then thick lake sediments partly filled the Seneca Lake depression in front of them. How much sediment and what kind of sediment occurs below the bottom of Seneca Lake has been well identified by geological studies using geophysical methods and direct sampling of sediments by coring (Mullins et al. 1996). The lake sediments consist mostly of thick layered lake clay and silt with some sandy zones interbedded and encapsulated by the clayey materials.

Seneca Lake drains to the north to Lake Ontario, and the time it takes water to flush from it, called the "residence time" ranges from 12 to 18 years (Bloomfield 1978; Michel and Kraemer 1995) depending on assumptions scientists use to quantify all the waters entering the lake and leaving it, precipitation (rain and snow), streams flowing into and out of the lake, ground water flowing into and out of the lake, and evaporation from the lake.

Salinity in Seneca Lake.

Salinity, which I express herein in terms of chloride concentrations, naturally enters the lake from precipitation, streams and ground water dissolving minerals in soils and bedrock. Road salt also has entered the lake during the past few decades, and in the past, unknown quantities of salt waste and unused brine from the salt industry.

Halfman et al. (2014) (Figure 2) compiled historical chloride concentrations in the Finger Lakes, and his compilation figure clearly shows historically higher salinity in Seneca and Cayuga Lakes than the other Finger Lakes, an observation initially reported by Berg (1963). The highest chloride concentrations in both Seneca and Cayuga Lake began to decline in the mid-1960's after implementation of the Safe Drinking Water Act and other regulatory controls over industrial discharge (Figure 2).

In any case, the highest salinity in Seneca Lake was 70 mg/L below drinking water standards for chloride (which is 250 mg/L). This chloride standard is based on taste and not health issues. At no time historically have chloride concentrations in Seneca

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approached NYSDEC or any other drinking water standards. Concentrations of chloride in Seneca Lake have decreased about 30% since the highest concentrations measured, and based on a simple extrapolated trajectory, should approach pre-increase levels of about 40 mg/L in the next 80 years or so, in the absence of more chloride being put into the lake. This simple visual extrapolation is consistent with Halfman et al.'s (2014) more detailed calculations using a mathematical budget approach, conceptually akin to evaluating a bank account. In this work, Halfman calculated the amounts of chloride "deposited to the lake per year", the chloride "withdrawn" from the lake per year through stream water leaving, and the chloride "saved" in the lake.

Determining the sources of the higher chloride levels in both Seneca and Cayuga Lakes remains an interesting academic exercise, but not pertinent to the fundamental question whether the proposed LPG storage facility poses a risk to the lake salinity. Briefly, Berg (1963) first hypothesized that the extra chloride came from groundwater discharge to the lake from the deep Salina salt. This ground water flow would start on ridges located on either side of the lake or topographic high areas south of the lake.

Wing et. al. (1995) then tested Berg's idea in the northern part of the lake basin by sampling lake and bottom sediment pore waters and found that the bottom waters of the lake in the summer were slightly (10% more) saltier than near the top of the lake. In contrast, the chloride concentrations in the lake sediments below the water were brine, in agreement with Goodman et al.'s (2011) mapping of a large zone of brine in sediments and rocks under the northern half of the lake basin.

So, chemical diffusion, the slow movement of chloride from very high concentrations in the lake sediment to low concentrations in the lake water explains the small increase of chloride in the lower lake waters as observed—but well below the concentrations of chloride in the lake during the mid-1960's and after. There must be other sources of salt to the lake other than slow chemical diffusion and delivery of salinity from precipitation and surface water, all of which constitute small amounts of the lake salinity budget calculated by Halfman et al. (2014).

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One source might be more rapid and direct transport of salt brine at groundwater springs focused at preferential flow paths. The chloride in this case would travel to the lake, "piggie back" with flowing ground water near the lake shore in a process called "advection." This brine discharge to the lake would necessarily have to be focused at isolated zones of higher permeability in the lake sediments, which mostly consist of "tight" low permeability inter-bedded clays and silts. Examples of such brine springs have been identified north of Seneca Lake by Goodman et al. (2011).

Climate Change

Climate change might also have contributed to increases in salinity to Seneca Lake over time. For example, increasing concentration of salinity up though the 1960's occurred during a sequence of droughts, which broke shortly after (http://www.ncdc.noaa.gov), and the climate has remained wetter ever since. During drought, the flushing time for water in the lake logically would be longer and this may have accentuated the effect on chloride concentrations added by brine discharged from groundwater seeps and diffused from lake sediments in its northern half.

Finally, prior to regulatory controls starting in the 1970's, the salt industry periodically disposed of brine in deep rock formations and released it into Seneca Lake. For example, Ahrnbrak (1975) documented how a brine discharge from a salt plant created a salt plume in the lake before the State precluded this disposal practice. Today, lake bottom salinity in the southern part of the Seneca Lake near old and existing salt solution mining operations is no different than elsewhere, ruling out contamination from surface discharge now.

So, while interesting from a basic science perspective, the question of why Seneca Lake salinity has varied in the past has absolutely no scientific bearing on whether plausible problems at the proposed LPG facility will lead to additional salinization of the lake.

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Plausible Scientific Risk of Failure of the LPG Storage

Opponents of the LPG storage facility have brought up two ways that salinity associated with the facility could lead to salinization of the lake, inferring that the amount of salt input logically could lead to exceeding drinking water standards of 250 mg/L. I address the plausibility of their arguments below:

Indirect Introduction of Salt to the Lake from the Crestwood LPG Storage Facility.

Contributed to support the petition submitted by Gas Free Seneca, Thomas Myers offers a scenario where additional salt may enter Seneca Lake by displacement of now static brines in lake sediment. Myers claims that pressure changes at the Finger Lakes storage facility will cause strain, actual deformation in solid salt for fully 20 miles to the north, which would then, in turn, deform lake clays 50 meters thick to "squeeze" brine from them into the lake. Let me make this clear. "Deformation" in this case implies that an approximately 20-mile long slab of solid salt, many hundreds of feet thick, will be either "pushed," or micro-fractured its entire length from Finger Lakes' storage facility to the northern half of Seneca Lake. Does this make sense? Of course not!

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Figure 3 shows a graph of the pressure of brine, various liquid hydrocarbons, pressure of rock and pressure needed to fracture rock with depth. Long-term pressure changes at the proposed facility would *be less than exist now* because propane weighs less than brine. The maximum pressure ever briefly applied to the system would be *less than lithostatic* (the "weight" of the rocks above the salt), and far less than the minimum stress necessary to deform and fracture rocks. None of the pressure differences involved during the operation of the Finger Lakes storage facility are any way analogous to the actual stresses that might, in fact, propagate solid rock deformation tens of miles. And salt and lake sediments are not aquifers in the first place. The lake clays are part of the shallow water table hydrogeologic system, not aquifers in it . Why? Both salt and varved lake clay have hydraulic conductivities too low to pass water meaningfully.

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With respect to Myers's notion, the proof of the pudding of his idea lies at the end of his supposed deformation, the varved clay lake sediments. Myers conveniently sets the lowest hydraulic conductivity of them at 0.001 meters per day (10^{-6} cm/s) to enable his "squeezing" idea to even work. Hydraulic conductivity is one of the material properties of soils, sediment and rock governing how fast water can move through them. But Myers sets his lower boundary for hydraulic conductivity for varved clays improperly. The hydraulic conductivity of varved lake clays has been known for decades to be 100 to 1000 of times *smaller* (e.g. Remenda et al., 1994). Water, in fact, moves *so* slowly in varved lake clays, even those fractured and not under lakes, that the water inthem is thousands of years old--fossil water. Myers further suggests that if the hydraulic conductivity were as high as sand, even more brine could be "squeezed" out through his conjectured pulse of deformation leading to pressure forcing brine out of the upper lake sediment—from 20 miles away south at the Finger Lakes storage facility. Is there more than a hundred feet of sand under the upper half of Seneca Lake? No. Why even suggest there might be?

Myers used false assumptions and analogies to meet his desired ends.

Release of Salt Directly from the LPG Facility

The highly engineered LPG facility makes it neigh impossible for releases of salinity from the facility to Seneca Lake to increase salinity to above drinking water standards by any plausible cause.

Opponents to this facility have suggested three catastrophic failure scenarios:

1. Failure of the Brine Ponds.

The DSEIS and the engineering reports which have been submitted clearly show that the design of two ponds storing brine will be essentially identical to that used for new

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municipal waste landfills, complete with leachate collection systems, multiple liners, and monitoring wells down gradient to identify any leakage. In addition, unlike municipal waste landfills, the ponds will be heavily bermed and plant technicians will walk around them daily to look for any leaks.

But let us assume one of the ponds for reasons I cannot imagine dumps all its brine undetected into Seneca Lake. Were this catastrophic failure to happen at either pond, lake chloride concentrations would increase by less a part per million, despite which pond failed catastrophically.

Were such an implausible scenario to occur, the brine from the pond would sink to the bottom of the lake and remain essentially in place sufficiently long enough for it to be pumped out to lower its density sufficient to allow the brine pool to normally mix at overturn. With physical removal of the brine salinity concentration in the lake would go up even less. But all this discussion is moot, because the hypothesis of such catastrophic failure speaks more to imagination than science. Complete failure of either pond, given the over designed engineering, is not a plausible scientific scenario.

2. Failure of the Subsurface Storage in the Salt Caverns

Brine and liquid propane both are incompressible fluids and therefore, by definition, the liquid-filled caverns cannot collapse like air filled ones, and move liquids out of them. How can a cavern fail by lowering the pressure in it still filled to the ceiling with incompressible liquid? It cannot.

Opponents also argue that earthquakes may open up non-self sealing faults in the Salina fault allowing brine to escape from the subsurface caverns to the lake, again, through thick almost impermeable lake sediments. First, the southern Tier of New York notably has almost no historical earthquake activity, and even a recent very small one reflected crustal adjustment many km below the salt (http://earthquake.usgs.gov/earthquakes/states/index.php?regionID=32).

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Earthquakes that cannot be felt or cause damage do not cause meaningful displacement and faults that can migrate up through thick sedimentary rock sequences. The southern Tier of New York is now located far away from a tectonic boundary that could lead to such large earthquakes--although hundreds of millions of years ago, when Europe and Africa crashed into North America, faulting did occur. Does it make sense to imagine that a similar situation occurs now or could occur now? No. The notion that severe earthquakes can cause catastrophic failure of the storage facilities consists of imagination with no backing other than desire to see it so.

In summary, it is my opinion that the operation of the LPG facility as proposed will not cause any salinization of Seneca Lake by any plausible scientific or engineering reason, catastrophic or otherwise. I evaluate the safety of this proposed facility using scientific and engineering based on my fundamental understanding of physics and geology coupled to simple common sense and detailed actual measurements and the long standing success of storing liquid gas in salt caverns, including nearby in New York State.

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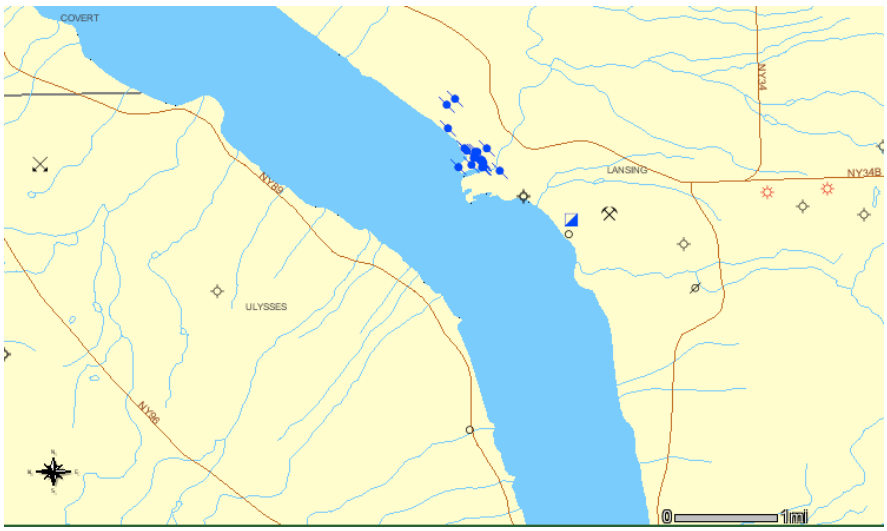

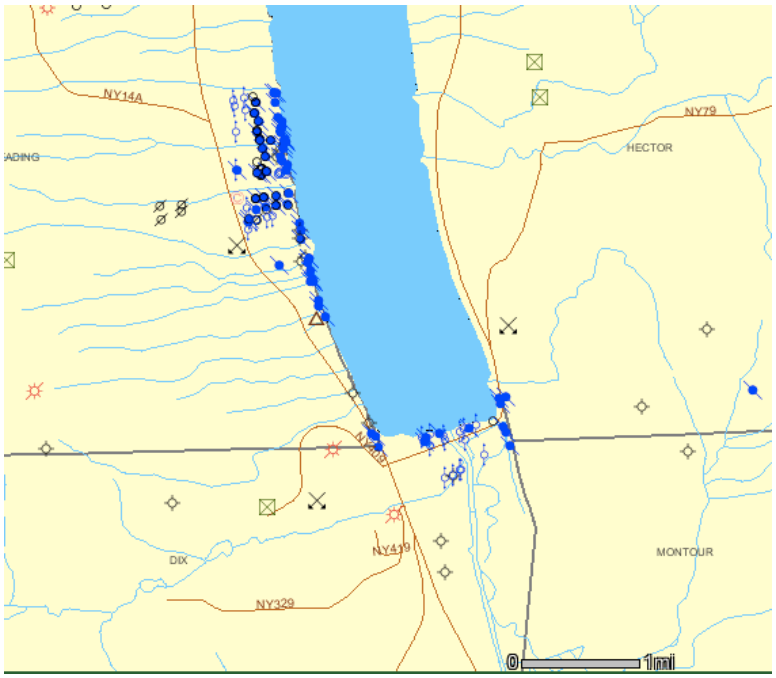

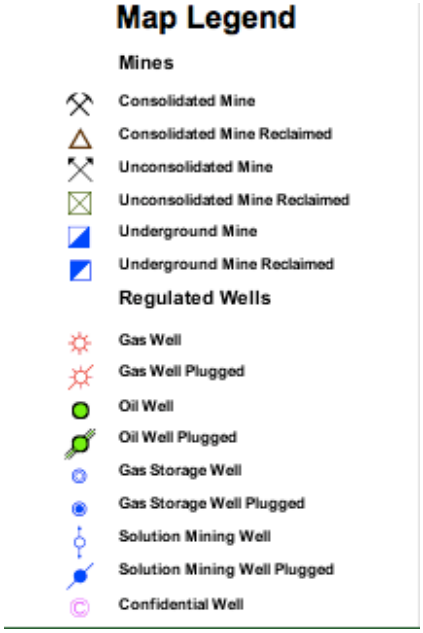

http://www.dec.ny.gov/imsmaps/minerals/viewer.htm

Figure 1. Salt Mining Activities on Cayuga (a) and Seneca (b) Lakes

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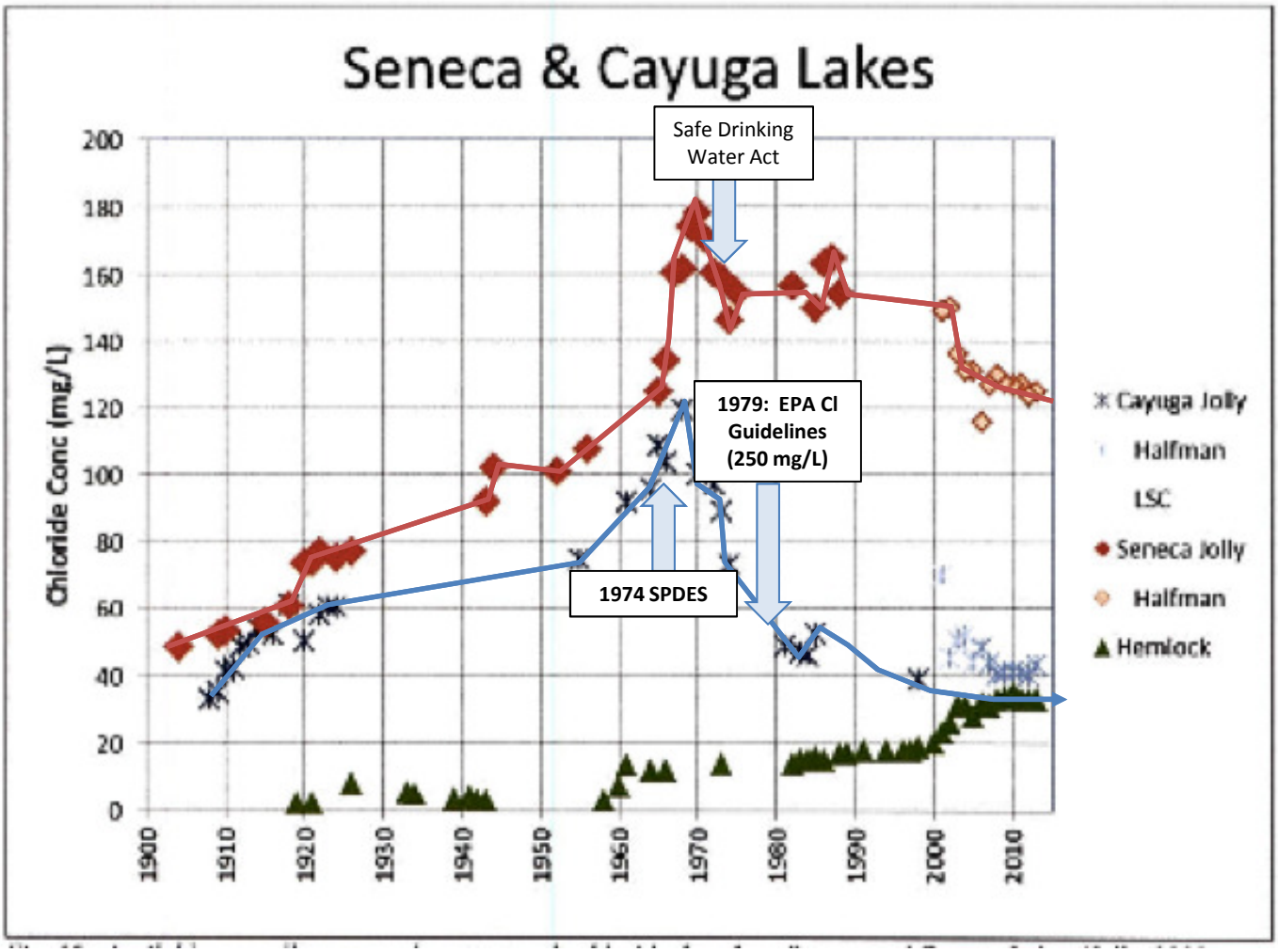

Figure 2. Historical salinity trends (as chloride concentrations), and initiation of regulations related to surface and groundwater Discharges (modified from Halfman et. al. 2014).

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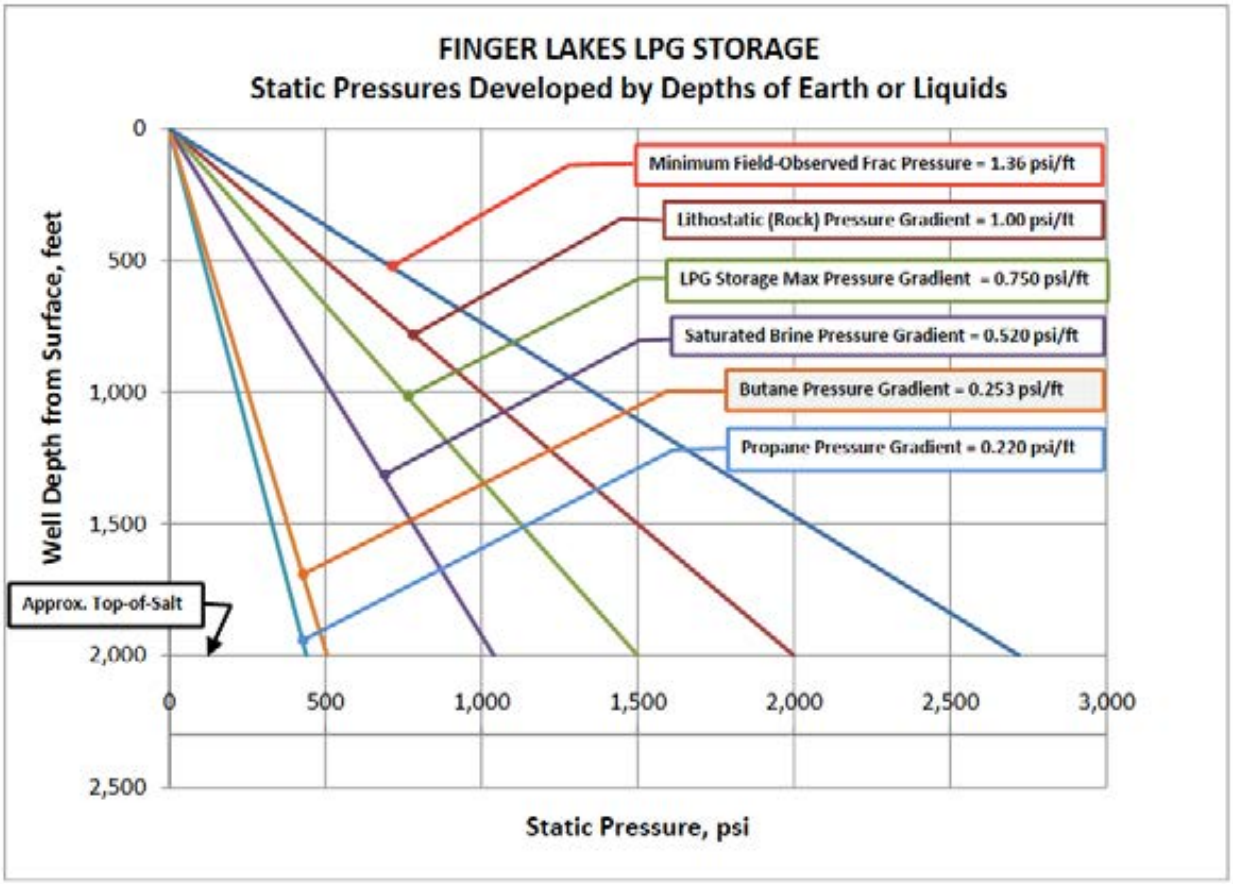

Figure 3. Pressure applied by different fluids compared to lithostatic pressure and the pressure need to hydraulically fracture rocks.

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QUANTITATIVE TRANSPORTATION RISK ANALYSIS FOR THE FINGER LAKES LPG TERMINAL

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QUANTITATIVE TRANSPORTATION RISK ANALYSIS FOR THE FINGER LAKES LPG TERMINAL

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QUANTITATIVE TRANSPORTATION RISK ANALYSIS FOR THE FINGER LAKES LPG TERMINAL

EXECUTIVE SUMMARY

Quest Consultants Inc.® was retained by Crestwood Midstream Partners, LP to conduct a quantitative risk analysis (QRA) on the LPG transportation modes associated with the Finger Lakes LPG terminal. Transportation of LPG is accomplished by pipeline, railcar, and tank truck. LPGs are transported and stored by the Finger Lakes facility in the form of either propane or butane. The storage, handling, and loading/unloading of these products was addressed in a separate QRA study conducted by Quest in 2012 (*Quantitative Risk Analysis for the Finger Lakes LPG Storage Facility*, February 16, 2012).

Current projections for the transportation of LPG by the Finger Lakes Project are:

- Most of the propane will arrive and depart through a short, newly-constructed pipeline connection. Approximately 5% is expected to depart by railcar.
- All of the butane will arrive and depart by railcar.
- No tank truck loadings or unloadings, with either propane or butane, are currently forecast.

The transportation QRA study was composed of the following steps:

- For each LPG transportation mode, define a range of potential hazardous events involving the release of LPG
- For each event, define the probability of occurrence
- For each event, define the impacts to members of the public should the event occur
- Combine the probability and impacts into measures of risk
- Assess the acceptability of the risk

The risk calculated by this QRA is defined as fatality risk to members of the public. All calculated values represent continuous occupancy – in other words, people are assumed to stay in the vicinity of the hazard (the transportation route) for 24 hours a day, 365 days per year.

When the transportation risks were assessed, it was found that the results of the risk analysis showed the risk to the public to be within acceptable ranges, by comparison to published international risk acceptance criteria. International acceptability criteria generally describe fatality risks to the public that are less than one chance in 1,000,000 per year as being acceptable. In addition, the risks due to LPG transportation (defined as probability of fatality) were compared to probability of fatality for "everyday" causes and found to be within the range of rare events.

The risk assessment findings can be summarized in the following ways:

- The annual probability of a fatality resulting from the transportation of LPG by pipeline ranges from about 1 in 66,670 per year directly above the pipeline to approximately 1 in one billion per year at locations 550 feet away, assuming an individual stays in the same place for an uninterrupted period of one year. The risk falls to zero at locations greater than about 750 feet away from the pipeline. The calculated risk associated with pipeline transportation of LPG exceeds the general acceptable risk criterion (i.e., greater than one chance in 1,000,000 per year) for the area within about 250 feet of the pipeline, along the entire pipeline route. However,

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because there are no residences in the vicinity of the Finger Lakes LPG terminal's pipeline (the pipeline is mainly within land controlled by the project), there is very little potential public exposure. **Conclusion: public risk due to LPG transportation by pipeline associated with the Finger Lakes LPG facility is minimal, and should be deemed acceptable.**

- According to the current (2014) estimates, LPG will not be transported to or from the Finger Lakes LPG facility by truck. **Conclusion: the added risk from the project due to LPG tank truck transport, based on current estimates, will be zero.**
- The annual probability of a fatality resulting from the transportation of LPG by railcar, for the Finger Lakes LPG facility, ranges from 1 in five million per year on the railroad track (assuming an individual remains on the railroad track for an entire year), to zero at locations greater than about 1,100 feet away from the rail line. The calculated risk associated with railcar transportation is less than the general acceptable risk criterion (i.e., less than one chance in one million per year) along the entire rail route. **Conclusion: the rail transport risk to the public due to the Finger Lakes LPG facility is minimal, and should be deemed acceptable.**
- When compared to other causes of death, the risk posed to the public by all LPG transportation modes associated with the Finger Lakes LPG terminal is also found to be minimal – approximately equal to being struck by lightning, and only if an individual stays in the same place within about 1,000 feet of a transportation route for an entire year, uninterrupted. For example, an individual is more likely to die from accidental poisoning or a motor vehicle accident than from a release from the Finger Lakes LPG pipeline, even when it is assumed that the individual remains in one place directly above the pipeline for one full year. Likewise, an individual is more likely to die from accidental choking, accidental drowning, surgical complications, or an earthquake than from the release of LPG from a railcar associated with the Finger Lakes LPG terminal. **Conclusion: public risks due to all modes of transportation associated with the Finger Lakes LPG facility are minimal, and should be deemed acceptable.**

Quest was also asked to review and comment on the report titled "*Independent High-Level Quantitative Risk Analysis: Schuyler County Liquid Propane Gas Storage Proposal*," dated January 14, 2015 and authored by D. Rob Mackenzie, MD, FACHE of Trumansburg, New York. The report provides an evaluation of the potential consequences of LPG transportation and storage accidents, as well as estimates of the frequencies or probabilities of such events. Quest's review of the risk assessment found several significant shortcomings in Dr. Mackenzie's work:

- Dr. Mackenzie has not demonstrated any expertise in hazardous chemical transportation risk analysis or petrochemical risk assessment.
- Dr. Mackenzie's risk assessment bases all consequences on qualitative descriptions of potential catastrophic events, ignoring accident scenarios with negligible or small consequences. A proper evaluation of public risk will integrate a wide range of possible event outcomes.
- The risk assessment does not properly calculate probabilities associated with the potential events associated with the Finger Lakes LPG terminal; the values are either calculated with an incorrect basis or overstate the frequency of serious events.
- The risk assessment does not properly account for the existing (presumably acceptable) risk in the county today. A proper comparative risk assessment would compare the existing risk to the future risk following commencement of operations at the Finger Lakes LPG facility.
- The risk assessment does not apply recognized methods for creation of risk measures that can be compared to risk targets in determination of acceptability or tolerability.

For the above reasons, Dr. Mackenzie's risk assessment cannot be deemed as valid or credible for use in determining the acceptability of the Finger Lakes LPG facility because it does not present a balanced approach to the actual risks posed to Schuyler County residents by the project.

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1.0 INTRODUCTION AND PROJECT OVERVIEW

Quest Consultants Inc.® was retained by Crestwood Midstream Partners, LP, to perform a quantitative risk analysis (QRA) on the transportation aspects of the Finger Lakes LPG Storage Project located in Schuyler County, New York. The Finger Lakes LPG terminal is designed to provide seasonal storage of liquefied petroleum gas (LPG) products (propane and butane), importing in the summer months by railcar and pipeline, and exporting in the winter months by railcar, pipeline, and (possibly) tank truck. Storage is accomplished with existing underground salt caverns.

The objective of the study was to evaluate the level of risk posed to members of the public due to potential releases of flammable fluids associated with movement of LPG to and from the storage terminal. To accomplish this, this work was divided into four parts:

1) Demonstrate the relative risks of transporting LPG by pipeline, railcar, and tank truck;
2) Based on the expected throughput at the plant and volumes to be transported by each mode, show the general risk for each transportation mode associated with the Finger Lakes LPG storage project;
3) Demonstrate some specific risk levels, at defined geographic locations, due to transportation of LPG to and from the terminal; and
4) Provide an overview and assessment of the risk to the public due to transportation of LPG to and from the terminal, as well as a technical review of a third-party risk assessment of the terminal's transportation and storage activities.

1.1 About Quest Consultants Inc.®

Quest Consultants Inc.®, formed in 1989, is an engineering consulting firm dedicated to providing process safety and risk management services to the petroleum and chemical industries. Our professional staff members are recognized leaders in process hazards analysis, consequence modeling, risk analysis, and safety-related research and testing. Many of Quest's staff have been involved in the process safety community for 20-35 years. Our beginnings, through the companies that preceded Quest, began with safety concerns surrounding liquefied fuels such as LNG and LPG. Through the development of process safety services that naturally extended into the entire petrochemical industry, Quest has grown into a company that offers a broad range of services that are supported with our own state-of-the-art consequence and risk analysis software. These services include regulatory compliance studies, process hazards analysis (PHA) studies, advanced consequence modeling, and quantitative risk analysis. Our engineers have provided services to a wide range of petrochemical operations, in locations around the world. These jobs have included numerous risk analysis and siting studies for entire refineries, LNG plants, LPG import/storage/export facilities, gas plants, and chemical facilities. In addition, Quest has made formal presentations of consequence and risk analysis results to clients, special interest groups, and governmental regulatory agencies.

1.2 Facility Description

The following facility description is based on information available to Quest, our knowledge of hazardous materials facilities similar to those included in this study, and codes and standards that are applicable to the facility that is the subject of this study.

The Finger Lakes LPG storage facility will be a multi-cycle LPG storage system with a major pipeline connection and rail and truck load/unload racks. The facility will be located in Schuyler County, New York, near the village of Watkins Glen and the town of Reading.

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The facility will consist of:

- underground storage caverns which will store the LPG;
- a rail and truck loading/unloading area with associated storage tanks, offices, and control facilities, located on NYS Route 14A;
- a new pipeline connecting to the TE Enterprise Products (Enterprise) facility;
- a plant area that will inject LPG into the storage caverns and transfer LPG between the storage caverns and the Enterprise pipeline or the rail and truck loading/unloading area;
- new pipelines to connect these portions of the project; and
- brine storage ponds to hold the brine displaced from the caverns as LPG is pumped in.

Figure 1-1 shows the proposed site layout, including the cavern wellhead locations, cavern transfer equipment, and the surface facility where the rail siding and truck loading area will be located.

Figure 1-1
Site Operations Plan

1.2.1 Underground Storage Caverns

LPG, consisting of butane or propane, will be stored in separate underground caverns in the Syracuse Salt formation on company owned property. The cavern designated for propane will store a maximum of 1.5 million barrels of liquid, and the cavern designated for butane will store a maximum of 600,000 barrels. The caverns were created by solution mining salt for consumer and other uses by US Salt (and its predecessors).

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Product can be delivered to the site either from the Enterprise pipeline or railcars. The caverns will initially be full of brine. Cavern injection pumps will transfer product to the caverns received from the Enterprise pipeline or from rail cars. The cavern injection pumps will increase the LPG pressure so it can be injected into a cavern, displacing brine. The process will be reversed during the withdrawal cycle when brine is pumped into the cavern and LPG is withdrawn.

1.2.2 Rail/Truck Area

A new facility located on NYS Route 14A will be built for the rail/truck loading and unloading area. This area will include the following facilities:

- six rail spurs;
- five 30,000 gallons aboveground storage tanks, each measuring 65 feet long and 8 feet in diameter, equipped with excess flow surge checks on the main liquid lines;
- three electric booster pumps to transfer product from the aboveground cylindrical tanks to the truck unloading rack or to the cavern injection pumps;
- six vapor compressors to be used in the rail car unloading process;
- an emergency shutdown system consisting of isolation valves and multiple personnel activation devices;
- a control and office building; a truck canopy (not fully enclosed) measuring 30 by 40 feet; three enclosed, heated and cooled kiosk buildings; and,
- site security including approximately 3,100 feet of chain link fence.

Product received by rail will be unloaded into the storage tanks using small vapor compressor units. Booster pumps will be installed to pump product from the storage tanks into a pipeline that connects the truck/rail area to the cavern injection pumps. During truck loading, the booster pumps will be used to pump LPG from the storage tanks into trucks through the truck loading rack. The truck rack is projected to be capable of loading 30 trucks per day with 2 bays. The rail loading area is projected to be capable of loading or unloading 24 rail cars in 12 hours with space to park 32 rail cars. Surge capacity will be provided by the storage tanks.

1.2.3 Storage Area

The plant storage area will include four electrically-driven pumps to be used to inject LPG into the caverns. Because LPG will be in contact with brine in the caverns, the facility will also include a separation vessel for butane and a molecular sieve drying system for propane. The molecular sieve system includes regeneration equipment consisting of a remote heater, heat exchangers, and the required process control systems.

The plant area also includes piping headers and valving to facilitate the movement of products into and out of the caverns (between the caverns and the pumps). Piping systems will also be in place to move product to and from the truck/rail loading area. The system will be equipped with automated valves to control the direction of product flow and to provide system isolation. The site will also include a small control building and a control center (MCC).

The facility will be connected to the nearby Enterprise facility by a buried pipeline approximately one-half mile long.

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1.3 Meteorological Data

Meteorological data for wind speed, wind direction, and Pasquill-Gifford atmospheric stability class used in this study were obtained from the National Climatic Data Center in Asheville, North Carolina, for the Ithaca, New York area. Ithaca was the closest location with full wind speed, wind direction and atmospheric stability data. A summary of the meteorological data used in this study is presented in Figure 1-2 as annual wind rose data for all stability classes. The length and width of a particular arm of the rose define the frequency and speed at which the wind blows from the direction the arm is pointing.

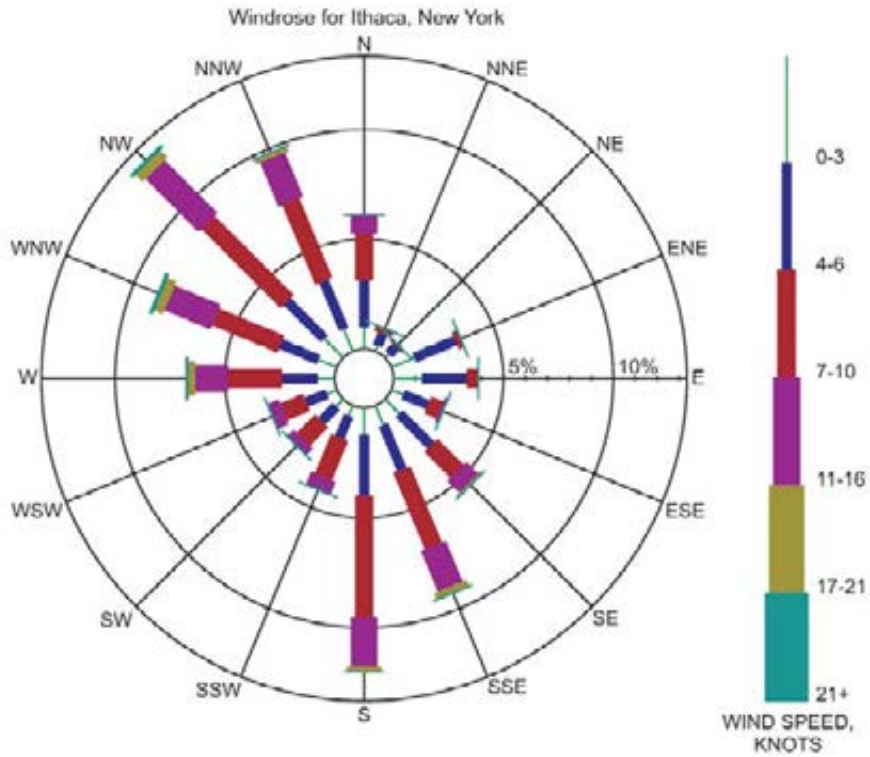

Figure 1-2
Annual Wind Rose Data for All Stability Classes for Ithaca, New York

Reviewing Figure 1-2 shows that the most common winds blow from northwest to southeast and from south to north. Since the weather data is developed from annual data (over many years), seasonal changes in wind magnitude, direction, etc. are already factored into the wind rose.

The data is divided into six wind speed classes, sixteen wind directions, and six atmospheric stability classes (defined as A through F). While not all of these combinations are possible, this range of data allows the differences in hazard zones due to atmospheric conditions to be integrated into the analysis.

Annual average values of air temperature and relative humidity were obtained from www.city-data.com (using Watkins Glen, New York data) and applied to the analysis.

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1.4 Scope of the Analysis

This QRA study evaluated the potential hazards to members of the public due to accidental releases from the Enterprise connection pipeline, LPG railcars moving in and out of the facility, and LPG tank trucks departing the facility. The hazards of vehicular accidents were not considered in this analysis. The flammable hazards of LPG associated with the Finger Lakes Storage terminal were evaluated in a separate QRA study *Quantitative Risk Analysis for the Finger Lakes LPG Storage Facility*, prepared by Quest, dated February 16, 2012. Neither of the QRA studies evaluated the potential hazards of brine usage associated with the storage caverns nor the potential environmental effects of brine releases.

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2.0 RISK ANALYSIS METHODOLOGY

All evaluations of risk in this study were accomplished through the application of a quantitative risk analysis. A QRA study is divided into four primary tasks.

Task 1. Determine potential releases that could impose hazardous conditions on the public.
Task 2. For each potential release identified in Task 1, derive the annual probability of the release.
Task 3. For each potential release identified in Task 1, calculate the potentially lethal hazard zones.
Task 4. Using a consistent, accepted methodology, combine the probabilities from Task 2 with the potential release consequences from Task 3 to arrive at a measure of the risk that is posed.

2.1 Hazards Identification

The potential hazards associated with the LPG transportation associated with the Finger Lakes project are common to LPG transportation activities worldwide. The hazards that are likely to exist are identified by the physical and chemical properties of LPG, the transportation conditions, design aspects of the transportation systems, and the safety features integrated into those systems. For the transportation modes considered in this study, the common hazards are:

- Torch fires (gas and liquefied gas releases)
- Pool fires (liquefied gas releases)
- Flash fires (gas and liquefied gas releases)
- Vapor cloud explosions (gas and liquefied gas releases)
- Boiling Liquid Expanding Vapor Explosions (BLEVEs) (major failures of railcars or truck-trailer tanks)

The hazards identification step is discussed further in Section 3.

2.2 Failure Case Definition

The potential release sources of hazardous fluids are determined from a combination of past history of releases from similar activities and location-specific information, including previous reports, accident data, and engineering analysis by system safety engineers.

This step in the analysis defines the various release sources and conditions of release for each failure case. The release conditions include:

- Fluid composition, temperature, and pressure
- Release rate and duration
- Location and orientation of the release
- Type of surface over which released liquid (if any) spreads

The failure case definition step is described in Section 3.

2.3 Failure Frequency Definition

The frequency with which a given failure case is expected to occur can be estimated by using a combination of:

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- Historical experience
- Failure rate data on similar types of equipment
- Service factors
- Engineering judgment

For single component failures (e.g., pipe rupture), the failure frequency can be determined from industrial failure rate databases. For multiple component failures (e.g., failure of an automatic system for preventing an uncontrolled release from a cargo transfer hose), Fault Tree Analysis (FTA) techniques can be used. The single component failure rates used in constructing the fault trees are obtained from industrial failure rate databases.

The failure frequency step and the database references are included in Section 4.

2.4 Hazard Zone Analysis

The release conditions (e.g., pressure, composition, temperature, hole size, inventory, etc.) from the failure case definitions are then processed, using the best available hazard quantification technology, to produce a set of hazard zones for each failure case. The CANARY by Quest® computer software hazards analysis package is used to produce profiles for the fire, explosion, and BLEVE hazards associated with the failure case. The models that are used account for:

- Release conditions
- Ambient weather conditions (wind speed, air temperature, humidity, atmospheric stability)
- Effects of the local terrain (diking, vegetation)
- Mixture thermodynamics

The hazard zone analysis step is included in Section 3.

2.5 Public/Industrial Risk Quantification

The risk quantification methodology used in this study has been successfully employed in many QRA studies that have undergone regulatory review in countries worldwide. This methodology is described in Section 5.

The result of the analysis is a prediction of the risk posed by the various transportation modes. Risk may be expressed in several forms (e.g., risk contours, average individual risk, societal risk, etc.). For this analysis, the focus was on the prediction of risk transects which describe individual risk as a function of distance from the transportation route.

2.6 Risk Assessment

Risk measures enable decision makers (i.e., corporate risk managers and regulatory authorities) to evaluate the risks associated with the hazardous material handling activity. Risk measures for the transportation of LPG can be compared to risk standards developed by several international agencies, as well as to other human activities in order to assist decision makers in making judgments about the acceptability of the risk associated with the terminal.

The results of the risk analysis, and conclusions drawn from this study, are presented in Section 6.

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3.0 POTENTIAL HAZARDS

3.1 Hazard Identification

Quest personnel reviewed the information related to propane and butane transportation modes associated with the Finger Lakes LPG facility. Using that information, a review of relevant transportation accident histories, our knowledge of and experience with transportation accidents, and good engineering practices, we determined the types of credible hazardous events that have some potential to occur for each mode of transportation. In general, these events can be divided into the following categories:

1) Small releases (leaks), characterized by ¼-inch diameter holes;
2) Moderate (punctures), characterized by 1-inch diameter holes;
3) Major releases, characterized by 3-inch diameter holes; and
4) Catastrophic releases, characterized by either
    - A rupture of the pipeline (full diameter break); or
    - A boiling liquid expanding vapor explosion (BLEVE) of a railcar or tank truck LPG vessel – a catastrophic failure of the vessel with a nearly instantaneous release of its contents.

3.1.1 Potential Hazards

Potential releases of propane or butane were considered for each mode of transportation considered in this study. Through the selection of a range of representative failure cases, the QRA involved the evaluation of many potential hazardous events. Each potential release may result in one or more of the following hazards.

1) Exposure to thermal radiation following ignition of a flammable fluid release, in the form of a torch fire or pool fire
2) Exposure to a flash fire following ignition of a flammable gas cloud
3) Exposure to explosion overpressure following the ignition of a flammable gas cloud
4) Exposure to the thermal radiation from a BLEVE fireball, which is the result of a catastrophic failure of a railcar or tank truck.

The remainder of Section 3 defines the techniques used to quantify these hazards.

3.2 Introduction to Physiological Effects of Fires and Explosions

The QRA performed on the Finger Lakes LPG facility involved the evaluation of many unique potential hazardous material releases. Each potential release may result in one or more of the hazards listed above. In order to compare and combine the risks associated with each type of hazard, a common measure of consequence must be defined. In risk analysis studies, a common measure for such hazards is their impact on humans. For each of the fire and explosion hazards listed, there are data available that define the effect of the hazard on humans.

For example, when comparing a fire radiation hazard to an explosive hazard, the magnitude of the hazard's impact on humans must be identically defined. It would not be meaningful to compare human exposure to nonlethal overpressures (e.g., low overpressures that break windows) to human exposure to lethal thermal radiation (e.g., 37.5 kW/m^2 for five seconds).

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In this study, risk is defined as the potential exposure of humans to lethal hazards (i.e., radiant heat, flash fire exposure, or explosion overpressure) that have the potential to occur as a result of accidents originating from LPG transportation accidents. The lethal exposure levels for the various hazards are discussed in the following sections.

3.2.1 Physiological Effects of Exposure to Flash Fires

The physiological effect of fire on humans depends on the rate at which heat is transferred from the fire to the person, and the time the person is exposed to the fire. Even short-term exposure to high heat flux levels may be fatal.

In the event of a flash fire (ignition of a flammable vapor cloud), persons inside a flammable vapor cloud (defined by the lower flammable limit or LFL) when it is ignited, without protective clothing are susceptible to flame exposure and short-term high radiation levels. Persons located outside a flammable cloud when it is ignited will be exposed to much lower heat flux levels. If the person is far enough from the edge of the flammable cloud, the heat flux will be incapable of causing injuries. Persons closer to the cloud, but not within it, will be able to take action to protect themselves (e.g., moving farther away as the flames approach, or seeking shelter inside structures or behind solid objects). Based on these principles, this analysis was based on the following:

- 100% fatality for persons outdoors and within a flammable vapor cloud (as defined by the LFL)
- 0% fatality for persons outdoors and outside of the flammable vapor cloud

The exposure to a flash fire (persons outdoors) assumes that no protective action is taken by the individuals potentially exposed to this hazard. In the event of a large flammable vapor cloud, there may be adequate time for personnel to move away from the flammable portion of the cloud and avoid being caught in a flash fire. However, many flammable clouds develop within seconds, and the limits of flammability are not readily discernible from visual observation. Thus, it was assumed that escape from a flammable cloud is not possible.

3.2.2 Thermal Radiation from Continuous Fires

In the event of a continuous fire (such as a torch or pool fire) following the release of flammable fluid, the thermal radiation levels necessary to cause fatal injuries to a person are defined as a function of exposure time. This is typically accomplished through the use of probit equations, which are based on experimental dose-response data.

For exposure to thermal radiation, the probit equation is developed in the form of radiation intensity (where the variable I is used for the radiation intensity) and exposure time (t) in seconds. Work sponsored by the U.S. Coast Guard [Tsao and Perry, 1979] developed the following probit relationship between exposure time and incident radiant heat flux.

$$Pr = -12.8 + 2.56 \ln\left(I^{4/3} \cdot t\right)$$

where: I = effective thermal radiation intensity, kW/m^2
t = exposure time, seconds

Table 3-1 presents the probit results for several exposure times that would be applicable for torch fires and pool fires. The fatality rates and corresponding thermal radiation levels are listed. The graphical form of the thermal radiation probit equation for different exposure times is presented in Figure 3-1.

Table 3-1
Hazardous Thermal Radiation Levels for Various Exposure Times Using the Tsao and Perry [1979] Thermal Radiation Probit

Exposure Time [seconds]	Probit Value	Fatality Rate [percent]	Thermal Radiation [kW/m^2]
5	2.67	1	27.87
	5.00	50	55.17
	7.33	99	109.20
15	2.67	1	16.57
	5.00	50	32.80
	7.33	99	47.39
20	2.67	1	9.85
	5.00	50	19.50
	7.33	99	38.60
30	2.67	1	7.27
	5.00	50	14.39
	7.33	99	28.47

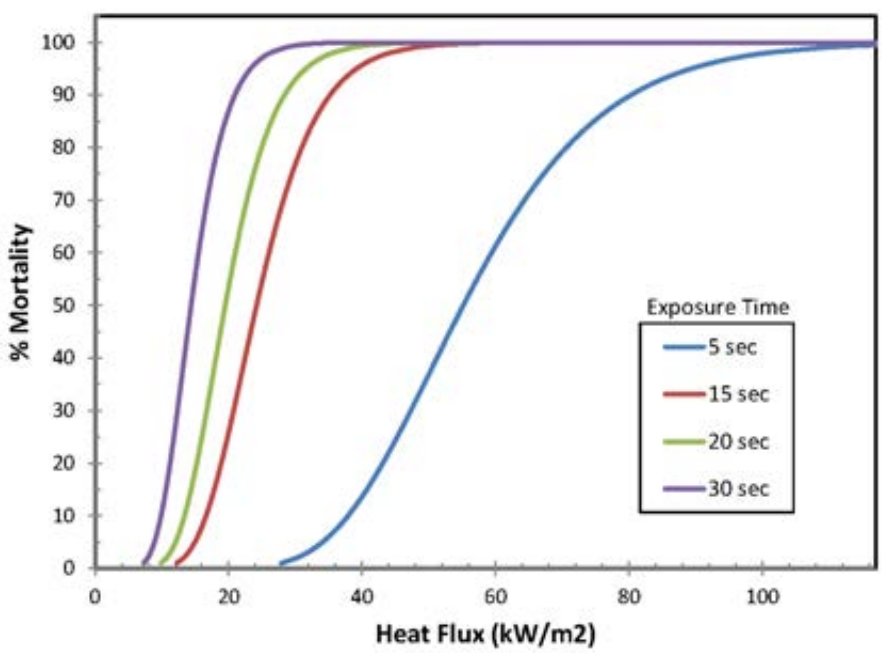

Figure 3-1
Incident Radiation Probit Functions

The choice of thermal radiation flux levels is influenced by the duration of the fire and potential time of exposure to the flame by an individual. All combinations of incident heat flux (I) and exposure time (t) that result in equal values of "radiant dosage" $\left(I^{4/3} \cdot t\right)$ produce equal expected fatality rates. The exposure time to radiative heat flux (from torch fires and pool fires) chosen for this analysis is 30 seconds. This is considered conservative (i.e., too long) as persons exposed to radiant hazards are aware of the hazards and in a very short period of time can either move towards a safer location or find a sheltered location.

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3.2.3 Physiological Effects of Overpressures

The damaging effects of overpressure on buildings depend on the peak overpressure that reaches a given structure, and the method of construction of that structure, as illustrated by Table 3-2. Similarly, the physiological effects of overpressures depend on the peak overpressure that reaches a person. Exposure to high overpressure levels may be fatal. If a person is far enough from the source of the explosion, the overpressure is incapable of causing fatality.

Table 3-2
Damage Produced by Blast Waves [Clancey, 1972]

Overpressure		Damage
psi	kPa	
0.02	.1	Annoying noise
0.04	.3	Loud noise (143 dB)
0.15	1	Typical pressure for glass breakage
0.3	2	10% window glass broken
0.5 - 1.0	3.5-7.0	Large and small windows usually shattered; occasional damage to window frames
0.7	5	Minor damage to house structures
1.0	7	Partial demolition of houses, made uninhabitable
1.3	9	Steel frame of clad building slightly distorted
2.0	14	Partial collapse of walls and roofs of houses
2.3	16	Lower limit of serious structural damage
2.5	17	50% destruction of brickwork of houses
3.0	20	Steel frame building distorted and pulled away from foundations
3 - 4	20-28	Frameless, self-framing steel panel building demolished
4.0	28	Cladding of light industrial buildings ruptured
5.0	35	Wooden utility poles snapped
5.0 - 7.0	35-49	Nearly complete destruction of houses
7.0	49	Loaded railcars overturned
7.0 - 8.0	49-55	Brick panels, 8-12 inches (203-305 mm) thick, not reinforced, fail by shearing or flexure
9.0	62	Loaded train boxcars completely demolished
10.0	69	Probable total destruction of buildings

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In the event of an ignition and deflagration of a flammable gas or gas/aerosol cloud, the overpressure levels necessary to cause injury to individuals are often defined as a function of peak overpressure. Unlike potential fire hazards, persons who are exposed to overpressure have no time to react or take shelter; thus, time does not enter into the hazard relationship. Work by the Health and Safety Executive, United Kingdom [HSE, 1991], has produced a probit relationship based on peak overpressure. HSE developed the probit based on V1 rocket fatalities in World War II. The analysis removed the effects of bomb shelters, accounted for building collapses, and included fatalities of persons both indoors and outdoors. This probit equation has the following form.

$$Pr = 1.47 + 1.37 \cdot \ln(p)$$

where: p = peak overpressure, psi

The graphical form of the overpressure probit equation is presented in Figure 3-2.

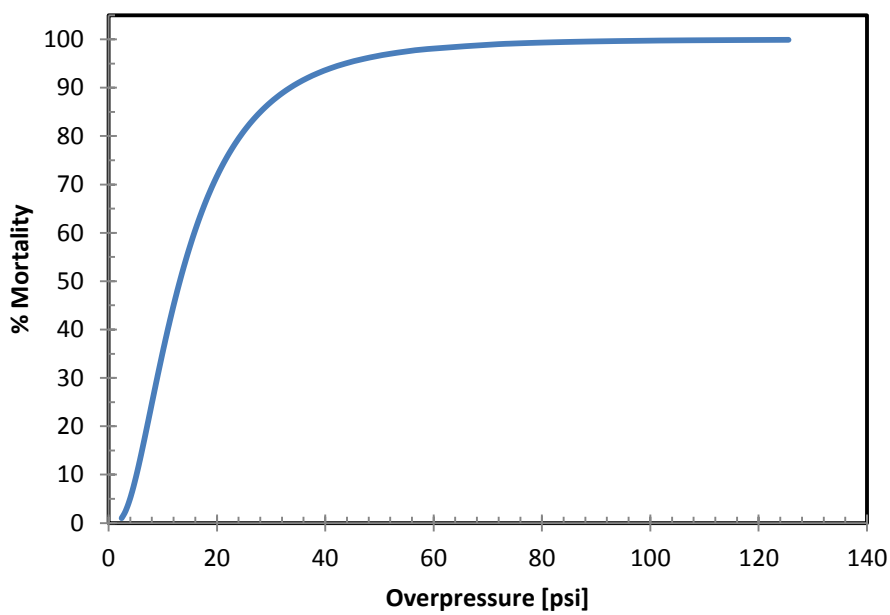

Figure 3-2
Overpressure Probit Relation

3.3 Consequence Analysis

3.3.1 Consequence Analysis Models

The hazard zones resulting from the selected releases were evaluated to determine the extent and location of vapor clouds containing propane and butane. When performing site-specific consequence analysis studies, the ability to accurately model the release, dilution, and dispersion of gases and aerosols is important if an accurate assessment of potential exposure is to be attained. For this reason, Quest uses a modelling package, CANARY by Quest®, that contains a set of complex models that calculate release conditions, initial dilution of the vapor (dependent upon the release characteristics), and the subsequent dispersion of the vapor introduced into the atmosphere. The models contain algorithms that account for thermodynamics, mixture behaviour, transient release rates, gas cloud density relative to air, initial

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velocity of the released gas, and heat transfer effects from the surrounding atmosphere and the substrate. The release and dispersion models contained in the QuestFOCUS package (the predecessor to CANARY by Quest®) were reviewed in a United States Environmental Protection Agency (EPA) sponsored study [TRC, 1991] and an American Petroleum Institute (API) study [Hanna, Strimaitis, and Chang, 1991]. In both studies, the QuestFOCUS software was evaluated on technical merit (appropriateness of models for specific applications) and on model predictions for specific releases. One conclusion drawn by both studies was that the dispersion software tended to overpredict the extent of the gas cloud travel, thus resulting in too large a cloud when compared to the test data (i.e., a conservative approach).

A study prepared for the Minerals Management Service [Chang, et al., 1998] reviewed models for use in modelling routine and accidental releases of flammable and toxic gases. CANARY by Quest® received the highest possible ranking in the science and credibility areas. In addition, the report recommends CANARY by Quest® for use when evaluating toxic and flammable gas releases. The specific models (e.g., SLAB) contained in the CANARY by Quest® software package have also been extensively reviewed.

CANARY also contains models for pool fire and torch fire radiation. These models account for impoundment configuration, material composition, target height relative to the flame, target distance from the flame, atmospheric attenuation (includes humidity), wind speed, and atmospheric temperature. Both are based on information in the public domain (published literature) and have been validated with experimental data.

For vapor cloud explosion calculations, Quest uses a model that is a variation of the Baker-Strehlow-Tang (BST) method. The Quest model for estimation of flame speeds (QMEFS) [Melton & Marx, 2009] is based on experimental data involving vapor cloud explosions, and is related to the amount of confinement and/or obstruction present in the volume occupied by the vapor cloud.

Technical descriptions of the CANARY models and QMEFS are presented in Appendix A.

QMEFS is based on the premise that the strength of the blast wave generated by a vapor cloud explosion (VCE) is dependent on the reactivity of the flammable gas involved; the presence (or absence) of structures such as walls or ceilings that partially confine the vapor cloud; and the spatial density of obstructions within the flammable cloud [Baker, et al., 1994, 1998], the average size of those obstacles, and the overall size of the vapor cloud [Mercx, 1994a, 1994b, 1997; Mercx, Van den Berg, & Van Dongen, 1996]. This model reflects the results of several international research programs on vapor cloud explosions, which show that the strength of the blast wave generated by a VCE increases as the degree of confinement and/or obstruction of the cloud increases. The following quotations illustrate this point.

> "On the evidence of the trials performed at Maplin Sands, the deflagration [explosion] of truly unconfined flat clouds of natural gas or propane does not constitute a blast hazard." [Hirst and Eyre, 1982] (Tests conducted by Shell Research Ltd., in the United Kingdom.)

> "Both in two- and three-dimensional geometries, a continuous accelerating flame was observed in the presence of repeated obstacles. A positive feedback mechanism between the flame front and a disturbed flow field generated by the flame is responsible for this. The disturbances in the flow field mainly concern flow velocity gradients. Without repeated obstacles, the flame front velocities reached are low both in two-dimensional and three-dimensional geometry." [van Wingerden and Zeeuwen, 1983] (Tests conducted by TNO in the Netherlands.)

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> "The current understanding of vapor cloud explosions involving natural gas is that combustion only of that part of the cloud which engulfs a severely congested region, formed by repeated obstacles, will contribute to the generation of pressure." [Johnson, Sutton, and Wickens, 1991] (Tests conducted by British Gas in the United Kingdom.)

Researchers who have studied case histories of accidental vapor cloud explosions have reached similar conclusions.

> "It is a necessary condition that obstacles or other forms of semi-confinement are present within the explosive region at the moment of ignition in order to generate an explosion." [Wiekema, 1984]

> "A common feature of vapor cloud explosions is that they have all involved ignition of vapor clouds, at least part of which have engulfed regions of repeated obstacles." [Harris and Wickens, 1989]

The strength of the blast wave predicted by the QMEFS VCE model is directly related to the size of the obstructed or partially confined volume that is assumed to be filled with a flammable mixture of gas and air, and five additional parameters.

Fuel Reactivity: A fuel's reactivity is characterized by its laminar flame speed. Because the QMEFS model is based on the BST model, flame speeds correlate to the BST categories of high, medium, and low. For example, ethylene, with a flame speed of approximately 76 cm/s was explicitly defined as a high reactivity fuel in the BST test series that defined that model. Most other fuels (propane, natural gas) have a flame speed between 40 and 45 cm/s, making them medium reactivity fuels.

Volume Blockage Ratio (VBR): The density of obstacles within the flammable cloud influences the peak overpressure due to the generation of turbulence along the flame front. VBR is defined as the fraction of a particular volume that is occupied by obstacles.

Number of Confining Planes: The number of confining planes affects the strength of an explosion, potentially limiting the expansion of the flame front. The number of planes can be any number from 0 to 6, but is typically limited to values of 1 ("3-D" flame expansion with ground reflection), 2 ("2-D" expansion, or what occurs between flat, parallel surfaces), or 1.5 ("2½-D", for situations that begin as 2-D and quickly transition to 3-D, or have one confining plane that is semi-porous or frangible).

Flame Run-up Distance: This dimension is a descriptor for the maximum distance which a flame front can travel within the burning cloud. As this dimension increases, the peak overpressure increases. This distance is typically limited to the longest horizontal dimension of the congested area.

Average Obstacle Diameter: As the size of obstacles decreases, the turbulence generated in a burning cloud increases, increasing the peak overpressure that is produced. The default value, from the BST test series is 2 inches (0.0508 m).

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3.3.2 Release Event Trees

A range of event scenarios was selected to cover the potential hazards associated with LPG transportation to and from the Finger Lakes facility. All releases were fully evaluated with the CANARY software and the QMEFS VCE model. For each accident scenario identified, several potential hazardous outcomes might be possible. These outcomes were identified by the construction of event trees for each release.

For any single accident scenario, several different potentially hazardous outcomes may develop, dependent on such factors as availability of ignition sources and the reactivity of the material (for overpressure potential). The chance that any single outcome will result from a release of material is dependent on these factors, as well as the size of the release.

An example of one of the event trees prepared for this study is presented in Figure 3-3. It begins with the release of propane from a pipeline. Moving from left to right, the tree first branches into four leak sizes, each identified by the diameter of the hole through which the fluid is being released. Each of these four branches divides into three branches based upon the ignition timing and probability. At this point in Figure 3-3, only the paths of the event tree releases from a piping leak (¼-inch) and from a rupture are shown. The same events are possible for the other two hole sizes and orientations.

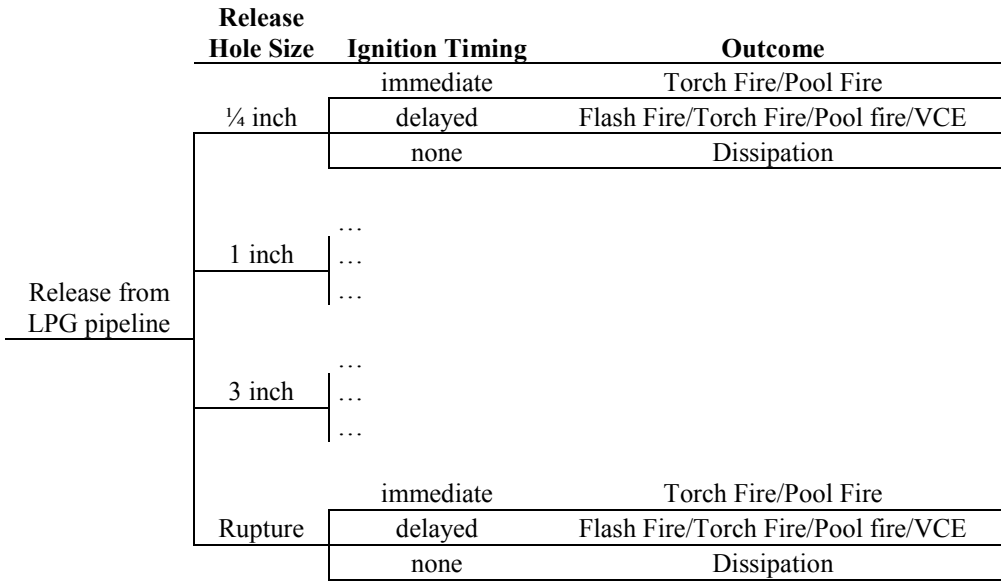

Figure 3-3
Event Tree for an LPG Pipeline Release

Immediate ignition of the release results in a torch fire and/or a pool fire. When not immediately ignited, the released material develops into a vapor cloud. At this point, ignition of the vapor cloud is called delayed ignition. Delayed ignition can result in several hazards. First, the flammable vapor cloud burns back to the release source as a flash fire. Next, if the vapor cloud has reached a confined or congested space, a vapor cloud explosion is possible. Lastly, a torch fire or a pool fire can result if material is still being released (torch fire) or the released material is present in the form of a liquid pool on the ground (pool fire). If the release does not find an ignition source, the outcome is dissipation of the flammable fluid. The right side of the event tree shows three outcomes that have some probability of occurring for each hole size/release orientation combination if the release occurs. The probabilities of the event outcomes are developed in Section 4.

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3.4 Analysis of a Superheated Liquid Release

For each release considered in this analysis, a number of consequence analysis calculations must be performed. As an example, this section evaluates the release of propane from the LPG pipeline between Enterprise and the Finger Lakes facility. The event tree for this type of release was presented in Figure 3-3. Probabilities for the event outcomes are developed in Section 4. For this type of release, the following sections describe the hazard calculations.

3.4.1 Flash Fire Hazards Following Release from the Propane Transfer Pipeline

The extent of the potential flash fire hazards is determined by the process conditions, hole size, wind speed, atmospheric stability, etc. A release from the pipeline is defined to be from one of four hole sizes. For this analysis, the following parameters were held constant during the evaluation.

- Relative humidity (average annual value = 70%)
- Ambient air temperature (average annual value = 53°F)
- Surface temperature (average annual value = 48°F)

A review of the weather data indicates that 21 of the 36 wind speed/atmospheric stability combinations exist (e.g., 10.36 m/s wind speed and F stability does not occur). A release from the liquid propane transfer line produces a vapor/aerosol cloud. Thus, for each hole size evaluated, 21 dispersion calculations to the lower flammable limit (LFL) must be made.

The calculated maximum momentum jet dispersion downwind extents to the LFL for the four hole sizes are presented in Tables 3-3 through 3-6. Table 3-3 presents the dispersion results in a matrix for a full rupture of the transfer pipeline when in propane service. Each element in the matrix presents the grade level downwind distance to the LFL under the wind speed and atmospheric stability class defined. As an example, for a full rupture of the piping, under 6.3 mph winds and D stability, the flammable cloud extends a maximum of 460 feet downwind of the release point. Tables 3-4, 3-5, and 3-6 present the momentum jet dispersion matrix results for major release (3-inch hole), puncture (1-inch hole), and leak (¼-inch hole) release scenarios.

3.4.2 Torch Fire Radiation Hazards Following Release from the Propane Transfer Pipeline

The extent of the potential fire hazards following a release from the propane transfer pipeline is determined by many of the same parameters that define the release rate for flash fire dispersion analysis. For torch fire calculations, the atmospheric stability is not an important parameter; thus, for each hole size, 12 torch fire thermal radiation calculations (one for each wind speed for immediate and delayed torch fires) need to be made. For this release scenario, a total of 48 fire radiation calculations are made for each release point (4 hole sizes x 6 wind speeds x 2 ignition times).

The distinction between immediate and delayed fires is based upon when ignition of a flammable release occurs. In general, the immediate torch fire will create a larger hazard due to the high mass flow during the initial seconds of a release. If a flammable fluid is ignited at some time after the release begins, the mass flow rate that feeds a torch fire is generally less. Thus, two torch fire outcomes are evaluated for each flammable gas/aerosol release scenario and each hole size.

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Results of the torch fire radiation calculations are summarized in Tables 3-7 and 3-8. Since the torch fire calculations are not a function of atmospheric stability, the matrix is defined differently than for vapor dispersion. Immediate torch fires for the four hole sizes are represented in Table 3-7. Delayed torch fire results are shown in Table 3-8. Thermal radiation endpoints defined by the probit analysis for 30-second exposure are listed in Tables 3-7 and 3-8 as 7.27 kW/m^2 (1% mortality), 14.39 kW/m^2 (50% mortality), and 28.47 kW/m^2 (99% mortality).

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Table 3-3
Summary of Momentum Jet Dispersion Flash Fire Downwind Distances for a Rupture of the Propane Pipeline

Endpoint: LFL = 2.1% (0.021 mole fraction) 100% mortality

Maximum Downwind Distance in Feet to Concentration Level

25.3 mph wind speed			30	50		
23.2 mph wind speed			35	55		
16.1 mph wind speed			40	65		
10.4 mph wind speed		35	55	85	515	
6.3 mph wind speed	45	45	215	460	635	660
2.3 mph wind speed	330	340	490	595		760
	A stability	B stability	C stability	D stability	E stability	F stability

Note: Existing wind speed/stability combinations are enclosed by the heavy line.

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Table 3-4
Summary of Momentum Jet Dispersion Flash Fire Downwind Distances for a Major Release (3-inch hole) from the Propane Pipeline

Endpoint: LFL = 2.1% (0.021 mole fraction) 100% mortality

Maximum Downwind Distance in Feet to Concentration Level

25.3 mph wind speed			30	50		
23.2 mph wind speed			30	50		
16.1 mph wind speed			40	60		
10.4 mph wind speed		30	50	75	480	
6.3 mph wind speed	40	40	200	445	630	655
2.3 mph wind speed	325	345	495	595		750
	A stability	B stability	C stability	D stability	E stability	F stability

Note: Existing wind speed/stability combinations are enclosed by the heavy line.

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Table 3-5
Summary of Momentum Jet Dispersion Flash Fire Downwind Distances for a Puncture (1-inch hole) in the Propane Pipeline

Endpoint: LFL = 2.1% (0.021 mole fraction) 100% mortality

Maximum Downwind Distance in Feet to Concentration Level

25.3 mph wind speed			20	30		
23.2 mph wind speed			20	35		
16.1 mph wind speed			25	35		
10.4 mph wind speed		25	30	45	275	
6.3 mph wind speed	25	25	45	270	405	430
2.3 mph wind speed	285	280	385	460		565
	A stability	B stability	C stability	D stability	E stability	F stability

Note: Existing wind speed/stability combinations are enclosed by the heavy line.

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Table 3-6
Summary of Momentum Jet Dispersion Flash Fire Downwind Distances for a Leak (1/4-inch hole) from the Propane Pipeline

Endpoint: LFL = 2.1% (0.021 mole fraction) 100% mortality

Maximum Downwind Distance in Feet to Concentration Level

25.3 mph wind speed			5	5		
23.2 mph wind speed			5	5		
16.1 mph wind speed			5	10		
10.4 mph wind speed		5	5	35	80	
6.3 mph wind speed	5	5	50	80	100	100
2.3 mph wind speed	90	95	120	140		150
	A stability	B stability	C stability	D stability	E stability	F stability

Note: Existing wind speed/stability combinations are enclosed by the heavy line.

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Table 3-7
Summary of Immediate Torch Fire Downwind Distances
for a Release from the Propane Pipeline

Endpoints:

7.27 kW/m^2	1% mortality
14.39 kW/m^2	50% mortality
28.47 kW/m^2	99% mortality

Maximum Downwind Distance in Feet to Thermal Radiation Level

25.3 mph wind speed	310 270 245	290 250 225	180 155 140	55 50 45
23.2 mph wind speed	315 270 245	290 255 225	180 155 140	55 50 45
16.1 mph wind speed	330 280 250	300 260 235	185 160 145	55 50 45
10.4 mph wind speed	345 295 255	315 275 245	195 165 150	60 50 45
6.3 mph wind speed	350 300 255	320 280 245	195 170 155	60 55 50
2.3 mph wind speed	350 295 245	320 280 245	195 170 155	60 55 50
	Rupture	Major Release (3 inch)	Puncture (1 inch)	Leak (¼ inch)

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Table 3-8
Summary of Delayed Torch Fire Downwind Distances
for a Release from the Propane Pipeline

Endpoints:

7.27 kW/m^2	1% mortality
14.39 kW/m^2	50% mortality
28.47 kW/m^2	99% mortality

Maximum Downwind Distance in Feet to Thermal Radiation Level

25.3 mph wind speed	255 220 195	240 205 185	180 155 140	55 50 45
23.2 mph wind speed	255 220 195	245 210 185	180 155 140	55 50 45
16.1 mph wind speed	260 225 195	245 215 195	185 160 145	55 50 45
10.4 mph wind speed	275 235 205	260 230 205	195 165 150	60 50 45
6.3 mph wind speed	280 240 200	270 235 205	195 170 155	60 55 50
2.3 mph wind speed	280 235 195	270 235 205	195 170 155	60 55 50
	Rupture	Major Release (3 inch)	Puncture (1 inch)	Leak (¼ inch)

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3.5 Thermal Radiation Hazards Associated with BLEVE Events

One catastrophic event associated with pressurized tanks storing liquefied gases (such as the cargo tanks on truck and railcars) is a Boiling Liquid Expanding Vapor Explosion (BLEVE). The BLEVE event is nearly always initiated by an external fire. The heat from the fire on the storage vessel raises the pressure in the vessel until the internal pressure exceeds the strength of the vessel. At the moment the tank loses structural integrity, the stored liquefied gas is instantly depressurized. A significant portion of the liquid quickly changes to vapor, and much of the rest is expelled outward as an aerosol. Because of the external fire, the aerosol cloud is immediately ignited, forming a fireball. This fireball is the primary hazard associated with the BLEVE phenomenon. The maximum thermal radiation hazard distances achieved by BLEVEs of the propane and butane pressure tank trucks and railcars in this analysis are presented in Table 3-9.

Table 3-9
Maximum Distance to Fatality Level Due to Radiant Exposure from BLEVE Events

Vessel	Duration of Fireball (seconds)	Distance (ft) to Fatality Level Due to Radiant Exposure from BLEVE Fireball		
		1%	50%	99%
Butane Railcar (30,000 gallons liquid)	13.1	1,030	700	445
Propane Railcar (30,000 gallons liquid)	13.1	1,025	695	440
Butane Tank Truck (10,000 gallons liquid)	9.6	610	405	250
Propane Tank Truck (10,000 gallons liquid)	9.5	610	405	245

3.6 Hazard Zones Associated with Vapor Cloud Explosions

Review of the areas surrounding the Finger Lakes LPG transportation corridors and experience with similar systems reveals that there are few locations in which a vapor cloud might reach a sufficiently obstructed or confined location. In such cases, if the vapor cloud is ignited, overpressures sufficient to cause damage may be created. These locations where sufficient confinement or congestion exists are typically located in areas where obstacles such as trees may exist. Most locations along a pipeline right-of-way, roadway, or rail line will feature a completely open area, surrounded by either more open area (fields, etc.) or lightly forested areas. Because of this, most potential vapor cloud explosions do not generate sufficient levels of overpressure to fatally harm the public. In addition, the varied nature of the areas surrounding any transportation route represents an obstacle to proper accounting for overpressure effects.

As an example, consider the potential flammable vapor clouds associated with a release of propane into a mostly open area. The peak overpressure from this event is less than 0.5 psi. Even if the vapor cloud is partially involved in a lightly forested area, the predicted overpressure is approximately 1.5 psi, less than the threshold for fatality as presented in Section 3.2.3. While each flammable vapor cloud and any resulting explosion overpressure (if the cloud is ignited) will vary by release hole size, orientation, wind speed, atmospheric stability, and wind direction, these results are generally characteristic of the potential explosions along the transportation routes associated with the Finger Lakes LPG facility.

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3.7 Summary of Consequence Analysis Results

Table 3-10 presents a summary of the maximum hazard distances that may be experienced due to releases from transportation activities associated with the Finger Lakes LPG terminal.

Table 3-10
Largest Hazard Distances for Finger Lakes LPG Transportation Releases

Release Description (Release From)	Maximum Distance (ft) from Release to Fatality Level			
	Flash Fire (LFL)	Pool/Torch Fire Thermal Radiation		
	100%	1%	50%	99%
Butane Railcar	570	225	200	190
Propane Railcar	780	245	235	230
Butane Tank Truck	520	210	185	180
Propane Tank Truck	775	245	230	225
Butane Pipeline	625	235	185	160
Propane Pipeline	760	350	300	255

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4.0 ACCIDENT FREQUENCY

The likelihood of a particular accident occurring within some specific time period can be expressed in different ways. One way is to state the statistical probability that the accident will occur during a one-year period. This annual probability of occurrence can be derived from failure frequency databases of similar accidents that have occurred with similar systems or components in the past.

Most databases that are used in this type of analysis contain failure frequency data (e.g., on the average, there has been one failure of this type of equipment for 347,000 hours of service). By using the following equation, the annual probability of occurrence of an event can be calculated if the frequency of occurrence of the event is known.

$$p = 1 - e^{(-\lambda \cdot t)}$$

where: p = annual probability of occurrence (dimensionless)
λ = annual failure frequency (failures per year)
t = time period (one year)

If an event has occurred once in 347,000 hours of use, its annual failure frequency is computed as follows.

$$\lambda = \frac{1 \text{ event}}{347{,}000 \text{ hours}} \cdot \frac{8{,}760 \text{ hours}}{\text{year}} = 0.0252 \text{ events/year}$$

The annual probability of occurrence of the event is then calculated as follows.

$$p = 1 - e^{(-0.0252 \cdot 1)} = 0.0249$$

Note that the frequency of occurrence and the probability of occurrence are nearly identical. (This is always true when the frequency is low.) An annual probability of occurrence of 0.0249 is approximately the same as saying there is a one in 40 chance, per year, of that event occurring.

4.1 Failure and Release Data

To develop a measure of risk that may be posed to the public due to the Finger Lakes LPG transportation systems, historical data for accidental releases of LPG from pipelines, railcars, and tank trucks must be obtained. This data provides the number of failures per mile of pipe, or failures per mile traveled for railcars and tank trucks. Development of these values is discussed in the following sections.

4.1.1 LPG Pipelines

Data is available from the U.S. Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) describing incidents involving hazardous liquids pipelines [PHMSA, 2011]. This data set was parsed to remove incidents that did not involve a release of hazardous liquid, in addition to incidents that were recorded in the database but did not involve releases from cross-country pipelines (such as releases from equipment in pump stations). Based on this data, an overall release frequency of 1.57×10^{-3} per mile per year was derived.

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4.1.2 Railcars

Data was obtained from the Surface Transportation Board (STB) Public Use Waybill Sample system. In that system, railcars are sampled at a 2.5% rate (every 40 railcars) to develop generalized data about the transportation of goods. For this analysis, the Standard Transportation Commodity Code (STCC) was used to find data for LPG railcars [STB, 2014]. Within STCC 29121, there are 15 commodities classifications, including propane, butane, isobutene, and LPG, among other similar materials. All of these commodities should be transported in containers equivalent to, or similar to, the DOT-112 railcars used for LPG.

Within this system, data was available for the years 2000 through 2012. In this 13 year time frame, it was found that STCC 29121 commodities travelled a total of 1,977,462,212 miles, averaging 152,112,478 miles per year. These miles are short miles, which represent the rail line distance between origin and destination. While short miles often do not include the total mileage due to necessary train movements, there is no reliable way to determine real, total miles. Thus, the short miles were used in this analysis with the realization that the failures per mile will be slightly less if real miles are used.

The number of releases associated with the 29121 commodity code was determined through utilization of two federal databases that contain logs for all railroad derailments and releases in the U.S. The Federal Railroad Administration (FRA) [FRA, 2014] and PHMSA [PHMSA, 2014] both record railroad incidents involving hazardous materials. Because incidents should appear in both databases, the use of both allows for better validation of the data. The FRA database references materials by their STCCs and the PHMSA database records hazardous material incidents by the UN Number of the material; therefore, a cross-reference was made to link the STCCs for the 29121 group to the applicable UN Number. Table 4-1 presents this cross-reference list.

According to the PHMSA database, during the 2000-2012 period, there were 18 derailment incidents that resulted in 40 releases of LPG-related materials (those materials listed in Table 4-1). Incidents which did not involve a release of hazardous material were not included in this count. The incident count result was validated through cross-referencing the events with the FRA database. Over the 13 year period, there was one incident reported in the FRA database which was not in the PHMSA database, and one PHMSA incident that was not in the FRA database. This discrepancy is likely due to improper reporting of the hazardous material on the incident report sheets.

Based on 40 release incidents and 1,977,462,212 miles traveled in the time frame of 2000-2012, a release rate of 2.02×10^{-8} per railcar-mile is calculated.

4.1.3 Tank Trucks

According to U.S. Energy Information Administration (EIA) data [EIA, 2014], there were 47 releases from liquefied gas tanker trucks in 2010. Due to lack of detailed data, a conservative assumption was made that all 47 of these releases involved LPG. (As with the STCC 29121 code for railroad transport, the classification of "liquefied gas" may include many materials; however, most of the truck loads are believed to be an LPG material.) The EIA also reports that liquefied gas tanker trucks traveled approximately 805,000,000 miles in 2010. Based on this 2010 data, which is considered representative of the yearly LPG truck activity in the U.S., a total release frequency of 5.84×10^{-8} releases per tanker truck-mile is calculated.

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Table 4-1
STCC Comparison List

Compound	STCC	UN Number
butane gas, liquefied	29121-10	UN1011
propane gas, liquefied	29121-11	UN1978
isobutane gas, liquefied	29121-12	UN1969
isomerate	29121-14	UN1268
dichlorobutene (1, 3-dichloro-2-butene)	29121-16	UN2920
ethylene, cryogenic liquid	29121-20	UN1038
Liquefied butene or isobutene	29121-22	UN1012
polyisobutylene	29121-23	UN1055
petroleum isopentane or pentane	29121-25	UN1265
propylene	29121-28	UN1077
coal gas	29121-30	UN1023
pintsch gas	29121-31	UN1971
petroleum by-product/impure butane, butylene or butadienes	29121-81	UN1071
isobutane for further refinery processing	29121-87	UN1969
liquefied petroleum gas, nec, compressed	29121-90	UN1075

4.2 Release Incident Events

In any release event, there are multiple potential event magnitudes. It is recognized that in any LPG release event, there are several possible release magnitudes, as well as the possibility of catastrophic events. As presented in Section 3, the following range of event scenarios was assumed:

- Leaks, represented by a quarter-inch diameter hole
- Punctures, represented by a one-inch diameter hole
- Major release, represented by a three-inch diameter hole
- Catastrophic failure, represented by the rupture of a pipeline, or the BLEVE of an LPG tank truck or railcar

The databases cited for the release frequencies from tank trucks and railcars (as presented above) do not provide sufficient detail regarding the release magnitude or hole sizes involved. Because of this, data external to these databases was applied for the conditional probability of various hole sizes. In the Hydrocarbon Releases Database (HCRD) [HSE, 2012], an industrial database published by the UK's Health and Safety Executive (HSE), all recorded events involved a release of hydrocarbon from processing equipment or piping. This database was evaluated over a 20 year period to develop a hole size

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distribution for process equipment release scenarios. While this is arguably not the same as LPG truck or railcar accident releases, the hole size distribution was considered representative of the accident scenarios recorded in the databases applied to this study.

For the pipeline, the PHMSA hazardous liquids pipeline incident database contains sufficient information such that a hole size distribution can be applied to the overall failure rate. This application of a hole size distribution accounts for the full range of releases from the LPG pipeline. However, for the tank truck and railcar events, there is no process equipment event that corresponds to a BLEVE (boiling liquid expanding vapor explosion). A BLEVE is typically a secondary event that is caused by an ignited release of flammable material, where the flame impinges on that or another vessel, eventually causing it to rupture catastrophically. The impinging flame provides ignition for the released material, and a fireball results.

There have been very few recorded BLEVE events for tank trucks or railcars in transit over the last few decades. Considering the data used in this analysis for release frequencies, no BLEVE events were recorded (2010 for tanker trucks in transit and 2000-2012 for railcars). To produce a tank truck BLEVE frequency, a publication by the International Association of Oil and Gas Producers (OGP) was referenced. This source provides a BLEVE frequency for tanker trucks of 4.19×10^{-9} BLEVEs per tank truck-mile, which is based on both "cold" failures and fire-induced BLEVEs.

For railcars, data for the 2000-2012 period were reviewed and no BLEVE events were found. The latest BLEVE incident occurred in Dragon, Mississippi, in 1992. This extends the time period to the previous 22 years in which only one BLEVE events was reported. If a smaller total annual mileage for LPG railcars is used to account for smaller LPG activity (for years between 1992 and 2000), then the one BLEVE involving LPG materials in that 22 year period (1992-2013) results in a BLEVE frequency of 3.28×10^{-10} per railcar-mile.

The above frequencies for BLEVEs were developed independently of the release frequencies. However, it is recognized that BLEVE events normally occur as part of another accident. Because of this, we must make an assumption that the BLEVE events were actually part of the recorded incident and release scenarios found in the databases. If we subtract the BLEVE frequencies from the derived release frequencies for tank trucks and railcars, the total frequency for leak, puncture, and major hole sizes for tank truck and railcar releases can be determined. The failure rates used in this analysis are summarized in Table 4-2. Note that the tank truck and railcar failure rates must be multiplied by the number of tank trucks or railcars that pass by a location each year to determine the total failure rate for a transportation route.

Table 4-2
Failure Rate Frequencies

Transportation Mode	Failure Rate Units	Leak	Puncture Release	Major Release	Pipeline Rupture or Tank Truck/Railcar BLEVE
Pipeline	Failures per mile per year	3.93×10^{-4}	2.69×10^{-4}	3.81×10^{-4}	5.76×10^{-4}
Tank Truck	Failures per tank truck per mile	4.94×10^{-8}	2.51×10^{-9}	2.27×10^{-9}	4.19×10^{-9}
Railcar	Failures per railcar per mile	1.81×10^{-8}	9.20×10^{-10}	8.31×10^{-10}	3.28×10^{-10}

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4.3 Hazardous Events Following Fluid Releases

A release of hazardous fluid to the atmosphere may create one or more hazardous conditions, depending on events that occur subsequent to the release. For a flammable fluid, the possibilities are:

a) No ignition. If a flammable vapor cloud forms but never ignites, there is no hazard.
b) Immediate ignition. If ignition occurs nearly simultaneously with the beginning of the release, the hazard may be thermal radiation from a torch fire (pressurized release) or pool fire (non-pressurized release).
c) Delayed ignition. If there is a time delay between the start of the release and ignition of the release, a flammable vapor cloud will form. After ignition, there will be a vapor cloud fire (flash fire), possibly followed by a pool fire or torch fire. If the flammable vapor cloud is contained, or partially contained, within a confined or congested space, then subsequent to ignition, the vapor cloud deflagrates, producing local overpressure.

Each of these three possibilities has some probability of occurring, once a release has occurred. The sum of these three probabilities must equal one. The immediate ignition probabilities employed in this study are taken from the TNO Purple Book [TNO, 1999]. This model accounts for the type of fluid released, the release rate, and the reactivity of the fluid. The delayed ignition probabilities employed in this study are developed according to the methodology published by the Energy Institute [UKOOA, 2006]. The delayed ignition methodology considers the number of potential ignition sources in the path of the dispersing cloud. As the number of encountered ignition sources increases, the probability of ignition increases.

Delayed ignition probabilities are dependent on the following factors:

- Release rate, release orientation, wind speed, and atmospheric stability - which together determine the size and shape of the flammable cloud,
- Wind direction,
- Release location, and
- The number and strength of ignition sources encountered by the flammable cloud.

Because of these factors, it is impossible to present the delayed ignition probability for any one failure case. Each failure case can have thousands of different delayed ignition probabilities, based on the specific factors associated with each unique accident scenario.

Event trees (such as Figure 3-3 in the previous section) were constructed within the risk mapping program for each failure case. Event trees incorporate the failure frequency for each hole size (as derived using the equipment count data and specific equipment failure rates), ignition probabilities, release orientation probabilities, and weather probabilities. In general, small releases are the most likely to occur and the least likely to be ignited (small probability of reaching an ignition source). The largest releases are the least likely to occur and the most likely to be ignited (highest probability of reaching an ignition source). The outcome probabilities from the event trees are combined with consequence outcomes in the risk mapping analysis described in Section 5.

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5.0 RISK QUANTIFICATION

The Finger Lakes Energy LPG project's transportation activities pose no health hazards to the public as long as flammable materials are not released into the environment. In the event of an accident that results in a release of flammable fluid, persons near the release point may be at risk due to the hazards posed by the release. The objective of this quantitative risk analysis (QRA) is to calculate the level of risk to the public. Once the risk level is calculated, it can be evaluated against applicable risk criteria.

5.1 Risk Quantification Methodology

The risk posed by hazardous materials is often expressed as the product of the probability of occurrence of a hazardous event and the consequences of that event. Therefore, in order to quantify the risk associated with hazardous fluids, it is necessary to quantify the probabilities of accidents that would release the fluids into the environment, and the consequences of such releases. The event outcome probabilities and associated consequences must then be combined using a consistent, accepted methodology that accounts for initiating event frequencies, conditional probabilities, the influence of weather conditions, and other pertinent factors.

The risk quantification methodology used in this study has been successfully employed in QRA studies that have undergone regulatory review in several countries worldwide. The following is a brief description of the steps involved in quantifying the risk to the public due to the Finger Lakes LPG facility.

Conceptually, performing a risk analysis is straightforward. For example, for releases of toxic or flammable fluids, the analysis can be divided into the following steps.

Step 1. Determine the potential credible events that could create a flash fire, torch fire, pool fire, vapor cloud explosion, or BLEVE. Potential release sources are determined from a combination of historical accident data, site-specific information, and engineering analyses by process safety engineers. Some of the factors that contribute to the selection of each unique event are:

a. Fluid composition, temperature, and pressure
b. Fluid inventory in the process
c. Hole size
d. Release orientation
e. Release location
f. Process controls and emergency shutdown systems

Step 2. Determine the frequency of occurrence of each hazardous event (f_{acc}), and for each event, all possible outcomes. The frequency of occurrence is a summation of the failure frequencies of all portions of the process where a release of hazardous fluid would result in a similar hazard. Individual failure frequencies are based on historical experience, failure rate data for similar equipment, service factors, emergency shutdown systems, and engineering judgment. The frequency of occurrence for each event outcome is calculated using event trees. An outcome's frequency is based on the event frequency and conditional probabilities of ignition and/or weather conditions.

Step 3. Calculate the size of each potentially fatal hazard zone created by each of the releases identified in Step 1.

i. The hazards of interest are:
   a. Exposure to a flash fire,
   b. Thermal radiation from a torch fire, pool fire, or BLEVE fireball, and
   c. Overpressure from a vapor cloud explosion

ii. The size of each hazard zone is a function of one or more of the following factors.
   a. Orientation of the release (e.g., vertical, horizontal or downward)
   b. Wind speed
   c. Atmospheric stability
   d. Local terrain (including impoundment)
   e. Composition, pressure, and temperature of fluid being released
   f. Hole size
   g. Vessel inventories
   h. Diameter of the liquid pool
   i. Presence of regions of confinement or congestion

Step 4. Determine the risk to the public in the vicinity of the hazardous material source.

i. The potential exposure to a specific hazard zone depends on the following factors.
   a. Size (area) of the hazard zone
   b. Location of the receptor, relative to the release location
   c. Wind direction

ii. Determine the exposure to each potential hazard zone.
   a. Perform flash fire and vapor cloud explosion hazard zone calculations for all wind directions, wind speeds, atmospheric stabilities, hole sizes, and release orientations.
   b. Perform torch fire and pool fire hazard zone calculations for all hole sizes, release orientations, wind speeds, and wind directions. (Fire radiation hazard zones are not dependent on atmospheric stability.)
   c. Perform BLEVE hazard zone calculations.

iii. Modify each frequency of occurrence f_{acc} identified in Step 2 by the applicable conditional probabilities. The conditional probabilities are divided into the following groups.
   a. $P_{orientation}$ = probability that hazardous fluid is released into the atmosphere in a particular orientation.
   b. $P_{wd,ws,stab}$= probability that the wind blows from a specified direction (wd), with a certain wind speed (ws), and a given atmospheric stability class, A through F ($stab$). Meteorological data are generally divided into sixteen wind directions, six wind speed classes, and six Pasquill-Gifford atmospheric stability categories. Although all 576 combinations of these conditions do not exist, a significant number will exist for each meteorological data set. Figure 5-1 represents a typical wind speed versus stability distribution.
   c. P_{ii} = probability of immediate ignition (i.e., probability that ignition occurs nearly simultaneously with the release).
   d. P_{di}= probability of delayed ignition (i.e., probability that ignition occurs after a vapor cloud has formed).

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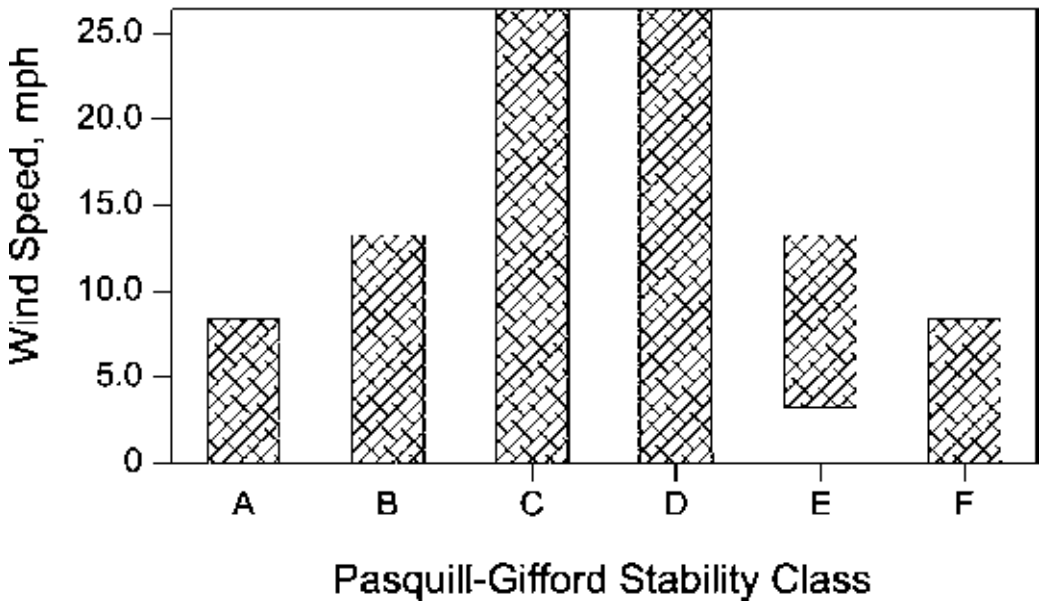

Figure 5-1
Representative Range of Wind Speed/Atmospheric Stability Categories for the Finger Lakes LPG Area

iv. Sum the potential exposures from each of the hazards for all releases identified in Step 1. This summation involves applying the frequency of each potential hazard zone to the areas covered by that zone. For example, the frequency of a specific flash fire is:

$$f_{flash\ fire} = f_{acc} * P_{orientaiton} * P_{ws,wd,stab} * P_{di}$$

5.2 Risk Presentation

Professionals in risk analysis realize there is no single measure that completely describes the risk a project poses to the public. Some risk analysts focus on the hazards of the various scenarios only, but this does not provide a full measure of risk. The risk measures used in this analysis are primarily risk transects. Risk transects are the most appropriate risk analysis measure for evaluating transportation activities.

5.2.1 Hazard Footprints and Vulnerability Zones

When conducting a quantitative risk analysis, it is necessary to determine for each potential release that is included in the study the probability of occurrence and the consequences of each possible combination of:

- hole size
- release orientation
- release outcome
- wind speed
- atmospheric stability
- wind direction

For each potential release, each unique combination of these factors results in a "unique accident."

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A hazard footprint can be defined as the area over which a given unique accident is capable of producing some level of undesirable consequences (e.g., 1% mortality, 3.0 kW/m^2, etc.). A vulnerability zone is defined as the area within the circle created by rotating a hazard footprint around its point of origin. Any point within that circle could, under some set of circumstances, be exposed to a hazard level that equals or exceeds the endpoint used to define the hazard footprint. However, except for accidents that produce circular hazard zones (e.g., explosions), only a portion of the area within the vulnerability zone can be affected by a unique accident. This is illustrated in Figure 5-2 by an example of a flammable vapor cloud hazard footprint (shaded area) and its vulnerability zone. In addition, many "smaller" accidents might be capable of producing hazard footprints that would affect parts of the vulnerability zone associated with a "large" accident.

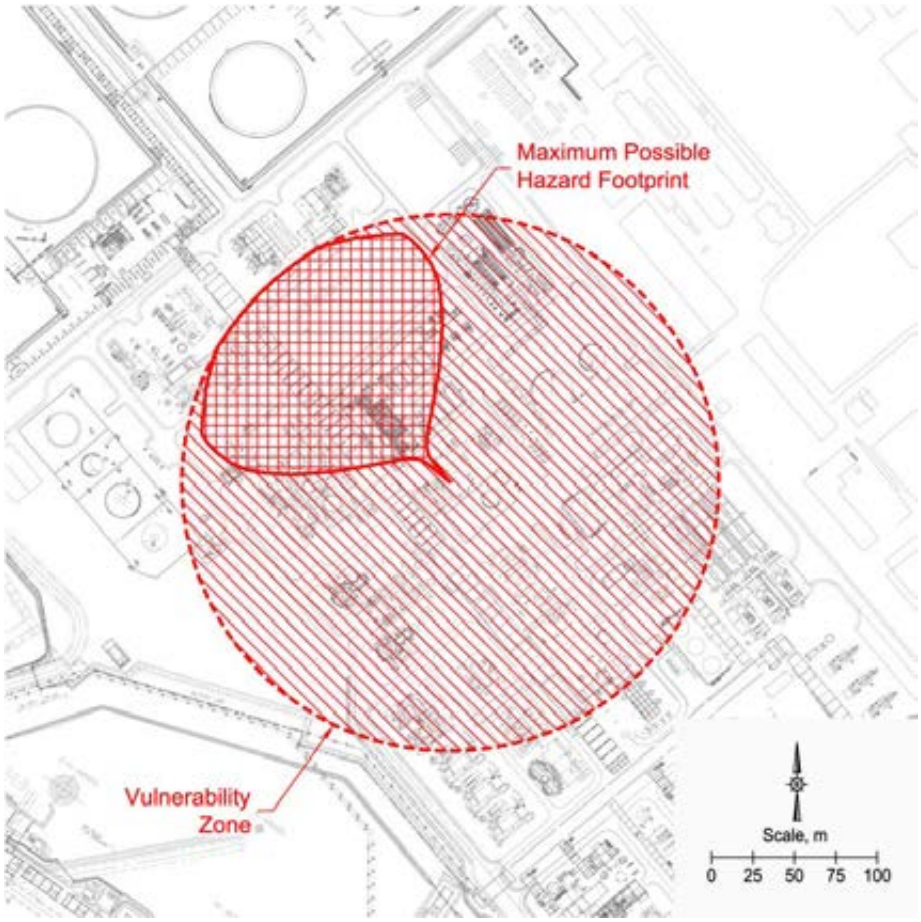

Figure 5-2
Example Hazard Footprint and Vulnerability Zone
(Example not Associated with the Finger Lakes LPG Facility)

Vulnerability zones can be used to define the size and shape of the area around a release within which there is a finite probability of exposure to a fatal hazard. Persons located outside this area would not be at risk from that unique accident scenario.

When the hazard vulnerability zone (the circle) on Figure 5-2 is presented, there is no associated probability since the cloud cannot cover the entire area at one time. In addition, there are other possibilities of cloud formation from the same release scenario that would fill a portion of the

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vulnerability zone. This risk analysis considered 20 combinations of wind speed and atmospheric stability and 64 wind directions for each unique release. These conditions were used when evaluating five release hole sizes and several event outcomes (flash fire, explosion overpressure, torch fire, and pool fire). The scenario presented in Figure 5-2 is just one of the thousands of possible outcomes following any given release. Thus, vulnerability zones are not a meaningful measure of risk. Vulnerability zones simply provide information about which areas could potentially be exposed to one unique accident, but provide no information about the probability of exposure.

5.2.2 Risk Transects

Risk transects demonstrate the location-specific individual risk (LSIR) as a function of distance from a line-source of risk. This presentation method is used as a representative measure for pipelines, rail lines, and trucking routes. They do not take into account the actual direction of, or specific location of, the transportation route. Because of this, the predicted risk represents a risk corridor at a perpendicular distance from the transportation route.

5.2.3 Terminology and Numerical Values for Representing Risk Levels

The risk an individual is potentially exposed to, by events that originate from the Finger Lakes LPG transportation modes can be represented by a numerical measure. This numerical measure represents the chance, or probability that an individual will be exposed to a fatal hazard during a year-long period. For example, a value of 1.0×10^{-6}/year (or 10^{-6} in shorthand notation) represents one chance in 1,000,000 (one million) per year of being fatally affected by a release originating in the facility. If this risk level is predicted to occur at a particular location, it represents the annual chance of fatality at that location, assuming a person stays in that location for the full year, due to any potential release from the facility's equipment. Table 5-1 lists the numerical value, the short-hand representation of that value as it is used in this report, and the value expressed in terms of chances per year.

Table 5-1
Risk Level Terminology and Numerical Values

Numerical Value	Shorthand Notation	Chance per Year of Fatality
1.0×10^{-3}	10^{-3}	One chance in 1,000 of fatality per year
1.0×10^{-4}	10^{-4}	One chance in 10,000 of fatality per year
1.0×10^{-5}	10^{-5}	One chance in 100,000 of fatality per year
1.0×10^{-6}	10^{-6}	One chance in 1,000,000 of fatality per year
1.0×10^{-7}	10^{-7}	One chance in 10,000,000 of fatality per year
1.0×10^{-8}	10^{-8}	One chance in 100,000,000 of fatality per year

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6.0 RISK ANALYSIS RESULTS

There are several methods available to present the risk associated with flammable fluid release events after the frequency and consequences are combined. Most methods define the level of exposure of the surrounding population in terms of probability of fatal exposure as a function of location. For transportation risk, the best method for presentation of risk is the risk transect. This measure defines fatality risk as a function of perpendicular distance from the transportation source, independent of population (or lack of population) around the transportation corridor. As presented here, the results assume a continuous public occupancy (24 hours/day, 365 days/year).

Three sets of risk transects were developed to describe the Finger Lakes LPG transportation risk:

- Comparison of LPG transport modes
- Risk associated with the current Finger Lakes LPG facility product flow assumptions
- Risk associated with the previous (2012) Finger Lakes LPG facility product flow assumptions

6.1 Comparison of Transportation Modes

The first set of risk transects were developed to demonstrate the relative risk of transporting LPG by pipeline, railcar, or tank truck. The expected throughput in the pipeline between the Enterprise facility and the Finger Lakes facility was chosen as a baseline for this assessment. The pipeline is expected to move (a sum of in and out movements) 2,925,000 barrels/year (122,850,000 gallons/year), and will only transport propane. The equivalent volumetric transport of propane in railcars and trucks was then calculated in order to set up the risk comparison. This volume of propane would require 4,095 loaded railcars per year (assuming a railcar holds 30,000 gallons), or would require 12,285 loaded tank trucks per year (assuming a tank truck holds 10,000 gallons). The resulting risk transects for this comparison are shown in Figures 6-1 and 6-2.

Figure 6-1 describes the risk from all potential releases from the pipeline, railcar, and tank trucks, including BLEVE events. If the BLEVE events (which apply to railcars and tank trucks only) are removed from the analysis, Figure 6-2 results. This differentiation is made for two reasons:

- BLEVE events are not well represented in the database and there is some uncertainty in the frequency values applied to the analysis.
- BLEVE events most often require some time to develop, due to the primary failure mode being catastrophic vessel failure due to external fire. This development time allows for the potential evacuation of persons in the area, which would remove this hazard from the imposed risk.

6.2 Current Product Flow Projections

The second set of risk transects is based on the current, anticipated product flows in and out of the Finger Lakes facility. The associated product movement volumes are given in Table 6-1. The railcar rates presented in Table 6-1 result in approximately 105 inbound loaded propane railcars per year, plus approximately 840 inbound and 840 outbound loaded butane railcars per year (for a total of 1,785 loaded railcars per year).

The resulting risk transects are presented in Figures 6-3 and 6-4. The same comparison is made in Figures 6-3 and 6-4 as in Figures 6-1 and 6-2, with Figure 6-4 showing the results without railcar BLEVE events.

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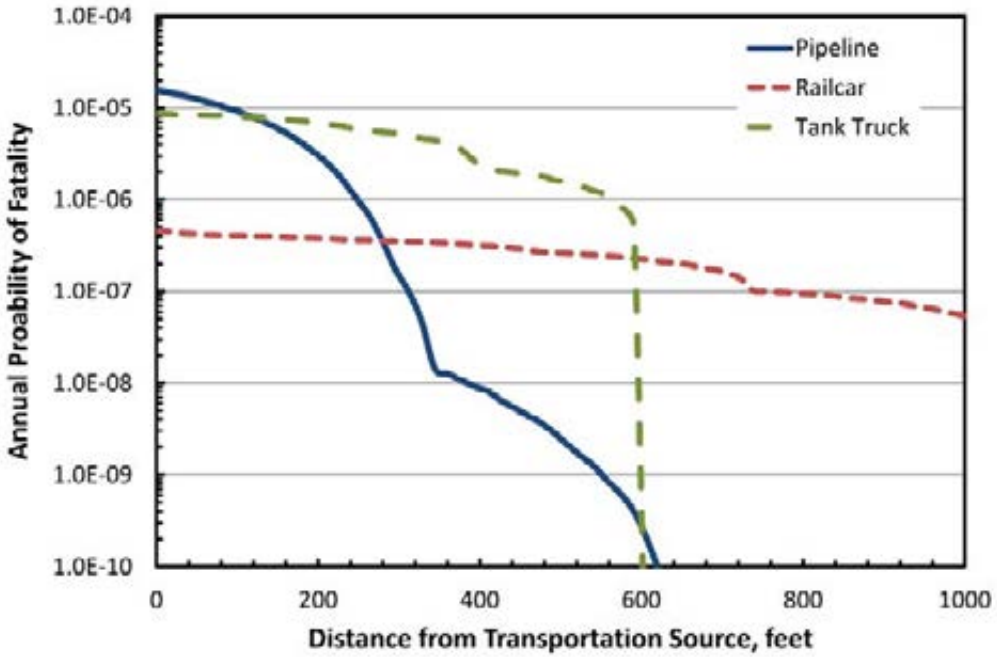

Figure 6-1
Risk Transects for 2,925,000 barrels/year Propane Transportation by Mode

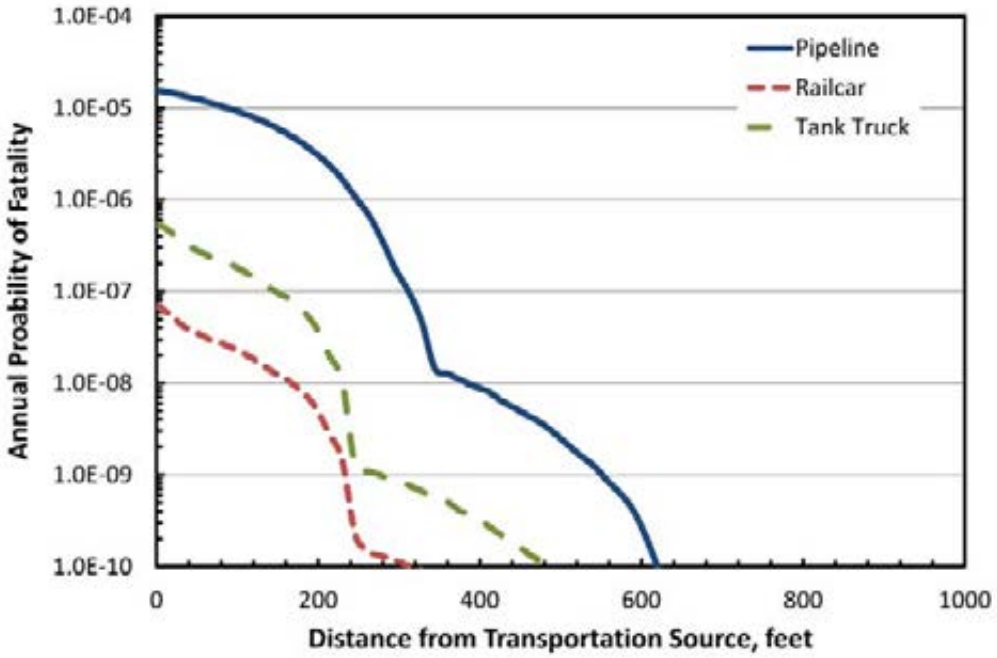

Figure 6-2
Risk Transects for 2,925,000 barrels/year Propane Transportation by Mode; No BLEVE Events

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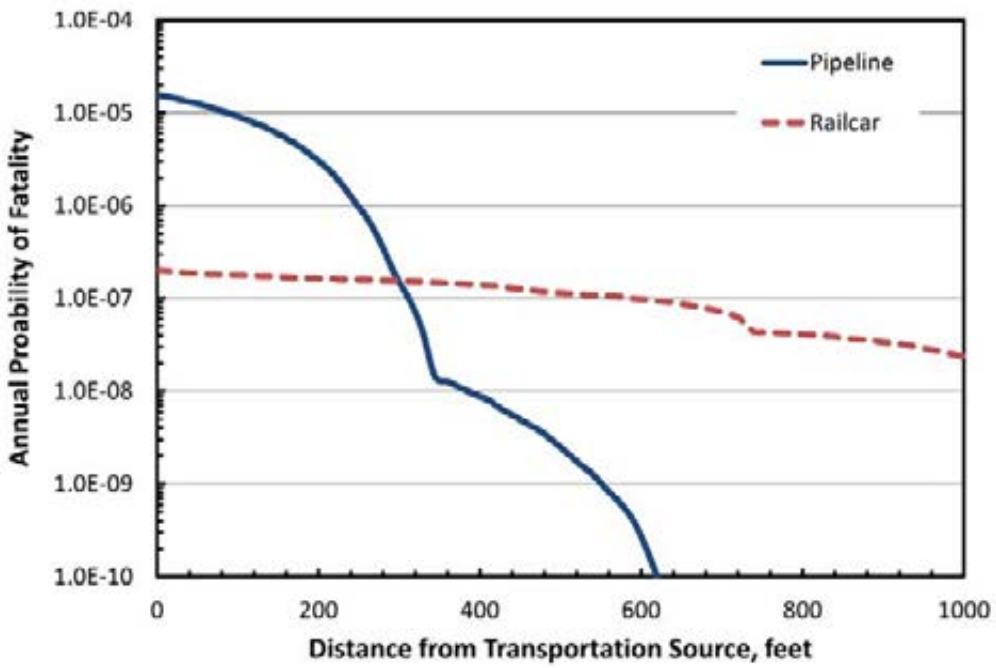

Figure 6-3
Risk Transects for the Finger Lakes Facility, Current Operating Projections

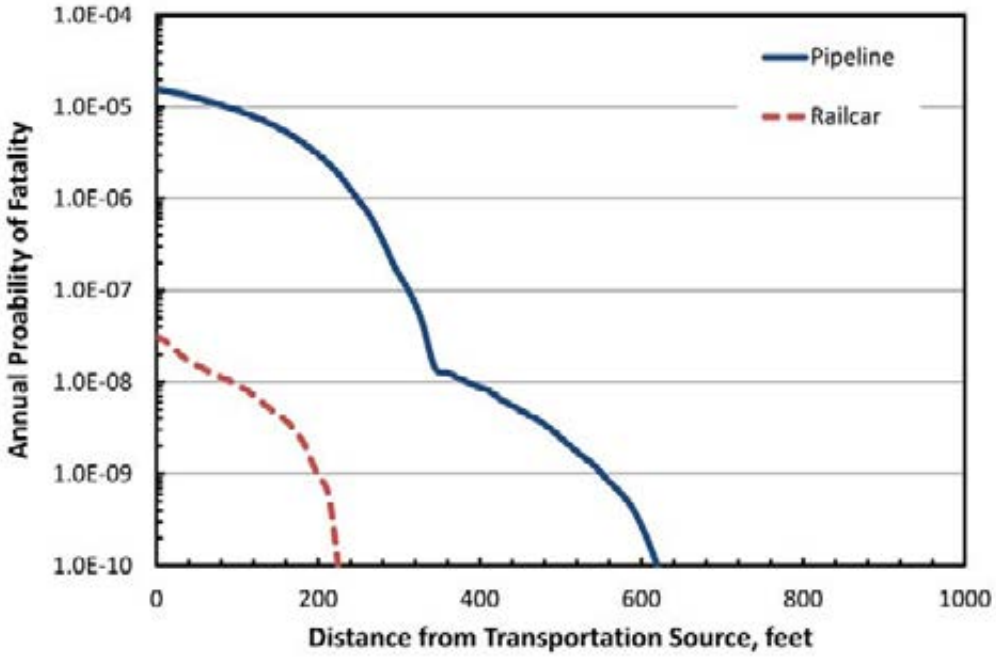

Figure 6-4
Risk Transects for the Finger Lakes Facility, Current Operating Projections; No BLEVE Events

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Table 6-1
Current Product Flow Assumptions

Product	Direction	Annual Volume Moved [barrels], by Mode		
		Pipeline	Railcar	Tank Truck
Propane	Inbound	1,425,000	75,000	0
	Outbound	1,500,000	0	0
Butane	Inbound	0	600,000	0
	Outbound	0	600,000	0

6.3 Previous (2012) Product Flow Projections

The third set of risk transects is based on the original (2012) projections for product flows in and out of the Finger Lakes facility. The associated product movement volumes are given in Table 6-2.

Table 6-2
Original (2012) Product Flow Assumptions

Product	Direction	Annual Volume Moved [barrels], by Mode		
		Pipeline	Railcar	Tank Truck
Propane	Inbound	1,350,000	150,000	0
	Outbound	225,000	150,000	1,125,000
Butane	Inbound	450,000	150,000	0
	Outbound	0	450,000	150,000

The rates presented in Table 6-2 are approximately equivalent to the railcar and tank truck movement rates presented in Table 6-3.

Table 6-3
Railcar and Tanks Truck Movement: Original (2012) Product Flow Assumptions

Product	Direction	Number of Loaded Vessels per Year	
		Railcars	Tank Trucks
Propane	Inbound	197	0
	Outbound	197	3,261
Butane	Inbound	197	0
	Outbound	591	435

The risk transects for the original product flow assumptions are shown in Figures 6-5 and 6-6. As with the previous two sets, the transects are shown with and without BLEVE events.

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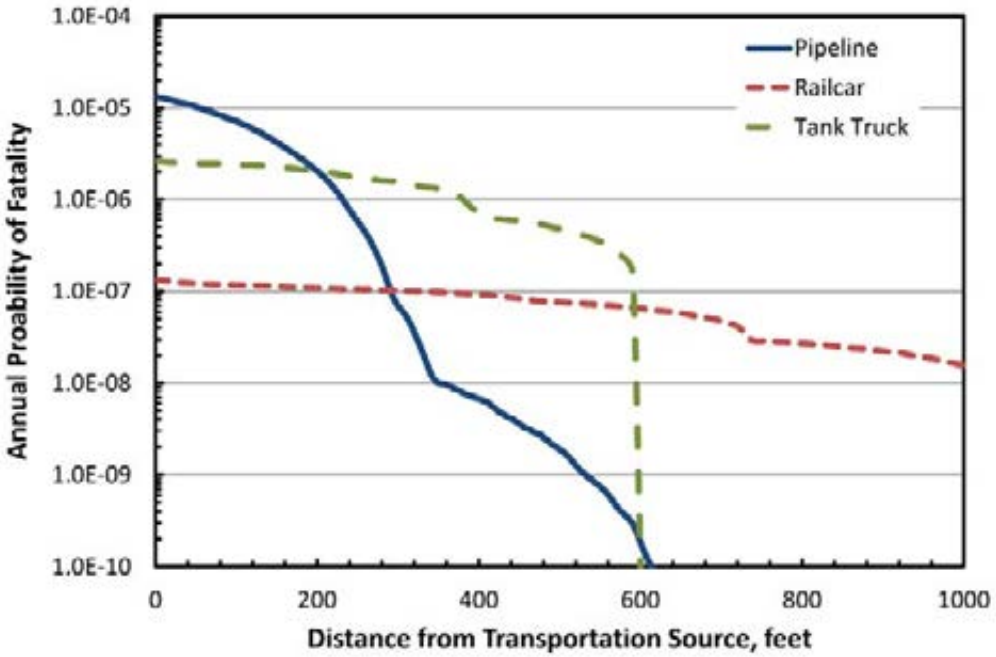

Figure 6-5
Risk Transects for the Finger Lakes Facility, 2012 Operating Projections

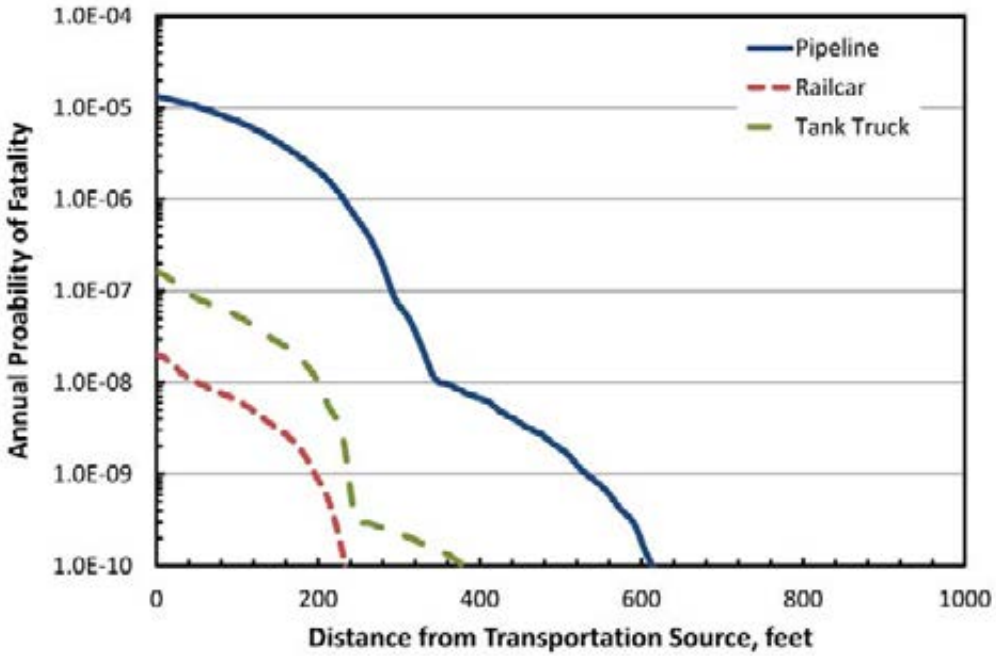

Figure 6-6
Risk Transects for the Finger Lakes Facility, 2012 Operating Projections; No BLEVE Events

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6.4 Conservatism Built Into the Risk Analysis Study

As with any consequence or risk analysis study, assumptions and engineering approximations are made in order to calculate the risk associated with the facility. In general, assumptions are made that tend to overpredict the risk due to releases from the project components. Thus, Quest believes that the predictions of risk presented in this report are conservative – in other words, they show the risk to be higher than it really may be.

A few of the conservative assumptions (that lead to risk overprediction) are listed below. The contributions of these factors cannot be explicitly quantified. They are presented here to provide qualitative reasons why the actual risk would be expected to be lower than predicted.

- **Overprediction of Public Presence**: The risk calculations assume that people are present outdoors, 24 hours a day, 365 days a year, at locations surrounding the LPG transportation routes. In areas where there are no public residences or business establishments, the risk to any member of the public is extremely small since most members of the public will not be continuously present near the transportation routes.
- **Overprediction of Flammable Cloud**: If a release did not ignite immediately upon release, no ignition sources were assumed to ignite a flammable cloud until the maximum downwind distance was achieved. This results in a significant overprediction of the risk since every flammable hazard is allowed to reach its maximum size in the analysis.
- **Ignoring Indoor Population**: This analysis did not account for any protection provided to members of the public due to being indoors. A building (or house) will provide shielding from thermal radiation (torch fires or BLEVE fireballs) and can provide protection against an ignited flammable gas cloud, provided that the gas cloud has not had sufficient time to infiltrate the building. This assumption is expected to result in an overprediction of the calculated risk.
- **Ignoring Human Response Time**: For persons exposed to fire radiation from a pool fire or torch fire, it was assumed that the duration of exposure was equal to thirty (30) seconds. This means that no protective or evasive action is taken by that individual for a full thirty seconds. If an individual moves away from the fire or finds shelter behind a solid object, their exposure to radiant energy will be reduced. Thus, the assumption of a 30-second exposure results in an overprediction of risk.
- **Ignoring Emergency Response Activities:** For some of the events modeled in this study, there is the possibility that emergency response activities could move members of the public to a safe location before the full hazard is realized. While this is primarily true for BLEVE events, it may also be true when members of the public are already in vehicles near the transportation route (assuming that they move away from the accident).

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7.0 RISK ASSESSMENT AND CONCLUSIONS

The results presented in the previous section are best interpreted when compared to risk criteria or other forms of risk. The following sections present several methods for use in determining the acceptability of public risk associated with the Finger Lakes Project LPG transportation modes.

7.1 Comparison with Baseline Risk

To fully evaluate the risk that the Finger Lakes LPG transportation activities may pose on the public, a comparison to the existing risk in the area is warranted. The transportation aspects of the project represent an *increase to existing* risks in Schuyler County. This is in contrast to the fixed facility portions of this project, which, as a new installation, have the potential to add *new* risk to the area immediately surrounding the installation. That risk was evaluated in Quest's 2012 QRA report and found to be generally acceptable with minimal public impact; please refer to that risk analysis for more information.

To properly evaluate the increased risk in the Schuyler County, consider the existing LPG transportation modes: A network of LPG truck loading and transfer points, as well as home delivery for storage and fuel use, is well established in the area. Loaded LPG tank trucks use most, if not all, roads in the area. Thus, any increase in LPG truck activity due to trucks departing the Finger Lakes LPG facility (trucks will only be loaded, not unloaded at this facility), can only add to the existing risk in the area. Furthermore, current expectations are that there will not be any LPG truck activity at the Finger Lakes LPG facility, and if there is, it will displace LPG truck activity at the nearby Enterprise facility.

Like the existing LPG truck activity, the Norfolk-Southern rail line passing through the county already has LPG railcars traveling on it, so the addition of loading/unloading railcars at this facility is not a new risk to the area. Finally, the pipeline between Enterprise and the Finger Lakes facility, although unique to the location where it will be installed, is not the only LPG pipeline in the county. An LPG pipeline already connects the Enterprise facility with supply from the U.S. gulf coast and continuing service to Selkirk, New York.

To quantitatively evaluate baseline risk, the risk analysis requires baseline numbers for transportation of LPG by the three modes evaluated in this study. Unfortunately, that information, in the format necessary for this type of analysis, was either not available or was only qualitative in nature. The information that was discovered includes:

- Pipeline: Schuyler County currently contains approximately 21 miles of LPG pipeline. The Finger Lakes LPG facility will add less than one-half mile of pipeline to that total.
- Rail: The only data point that was available suggested that there were 9 railcars of LPG that travelled on the Norfolk Southern rail line passing through Schuyler County in 2012. While the number of projected railcars associated with the Finger Lakes LPG facility will be significantly more, they are expected to arrive and depart from the south. Between the Finger Lakes LPG rail terminal and the county line, there are approximately 12 miles of rail (on the Norfolk Southern rail line). This project is not expected to cause any LPG railcar activity on the northern extent of the Norfolk Southern rail line, nor on the Finger Lakes Railway.
- Truck: As stated above, there is an expansive network for LPG truck deliveries within the entire county. No data was available concerning the truck volume that would be present on any specific road in the county. Based on Crestwood's latest projections, there will be no loaded LPG trucks leaving the Finger Lakes LPG facility.

Based on this set of information, it is clear that LPG transportation risk is not a new to the county. However, because there is not a definitive way to measure existing risk, nor a quantitative means to

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calculate the baseline LPG transportation risk, the risk due to the Finger Lakes LPG facility transportation activities calculated by this study (as presented in Section 6) must be assessed in other ways.

7.2 Risk Acceptability Criteria

There have been a few attempts to define acceptability criteria for public risk associated with hazardous fluids facilities. In general, such risk criteria have been developed to help regulatory agencies define where permanent housing or other public projects should be developed near industrial areas. Currently, there are no regulatory criteria applicable to this project, for either New York or the U.S.A.

On an international basis, risk assessors and regulatory bodies in places such as the United Kingdom, Australia, Canada, and the Netherlands [Meyer et. al., 2007] [CSChE, 2004] have defined fatality risk levels less than 1.0×10^{-6} per year (or one chance in 1,000,000 per year) as generally acceptable (or tolerable) for public residential areas. Risk levels of 1.0×10^{-6} per year and higher are generally seen as unacceptable for public areas where there are residences, schools, or other high-density populations. In some regulatory systems, risk levels between 1.0×10^{-6} per year and 1.0×10^{-4} per year (one chance in 10,000 per year) are defined as acceptable, depending on the land use. There are generally no criteria for public areas that are unoccupied (undeveloped) or used for agricultural purposes. All of the established regulatory criteria are based upon continuous occupancy; a risk analysis must incorporate occupancy factors, as applicable, if they are to be considered.

7.3 Risk Summary for the Finger Lakes LPG Transportation Activities

Based on a review of the information presented in Section 6, the following assessment of potential public impacts can be made:

- The risk associated with the Enterprise connection pipeline is approximately 1.5×10^{-5} per year (about one chance in 66,670 per year) at locations directly over the buried pipe, assuming continuous occupancy, declining to zero at approximately 750 feet away from the pipeline route. Annual exposure above 1.0×10^{-6} per year (one chance in 1,000,000 per year) is found within about 250 feet of the pipeline, assuming continuous occupancy.
- According to the current (2014) estimates, there will be no LPG truck activity into or out of the Finger Lakes LPG facility. This means that the incremental risk from the project due to LPG tank truck transport will be zero.
- For either the current or 2012 projections, the risk due to LPG railway movements, assuming continuous public occupancy, is predicted to be approximately 2.0×10^{-7} per year (or one in 5,000,000 per year) on the railway, declining to zero at about 1,100 feet away from the rail line.

The application of the 1.0×10^{-6} per year (or one chance in 1,000,00 per year) acceptability criteria is demonstrated with respect to the risk transects in Figure 7-1 for the current (2014) operating projections associated with the Finger Lakes LPG facility. The approximate zone of acceptable risk is shown as the shaded area in that risk transect figure. As seen in Figure 7-1, the public risk due to railcar transport of LPG is below the one in one million per year threshold. The public risk due to pipeline transport of LPG is above the threshold, but only within about 250 feet of the pipeline route.

Figure 7-2 provides the same demonstration for the 2012 product flow assumptions. As seen in that figure, the pipeline risk is above the threshold within about 230 feet of the pipeline route and the public risk due to tank truck LPG transport is above the threshold within about 380 feet of the roadway, given the 2012 projected volume of LPG truck traffic. As with the current projections, the public risk due to railway transport of LPG is below the one in one million per year threshold.

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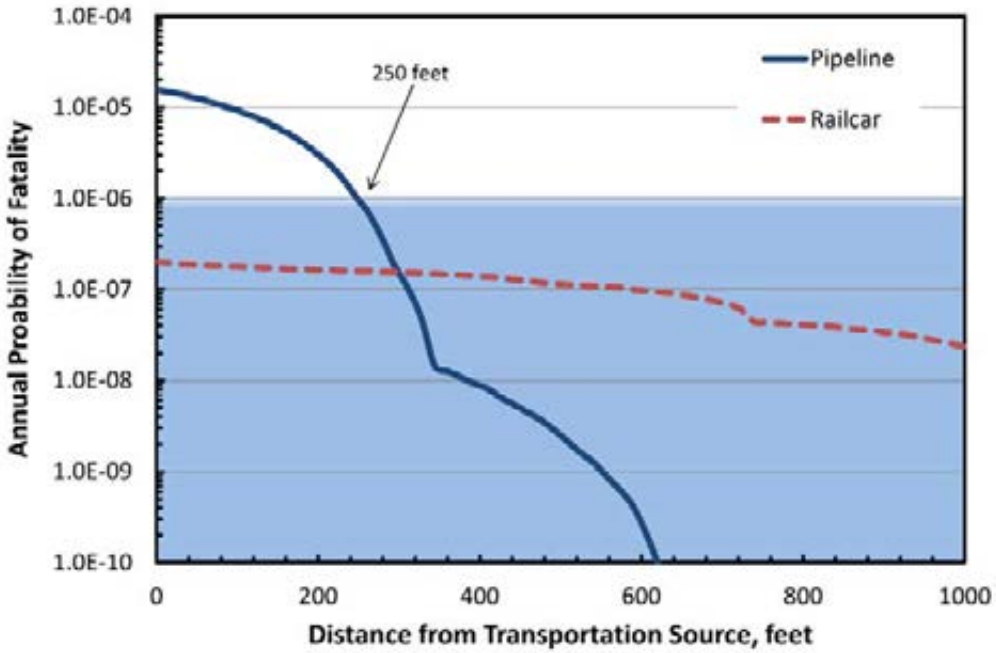

Figure 7-1
Risk Transects for the Finger Lakes Facility, Current Operating Projections

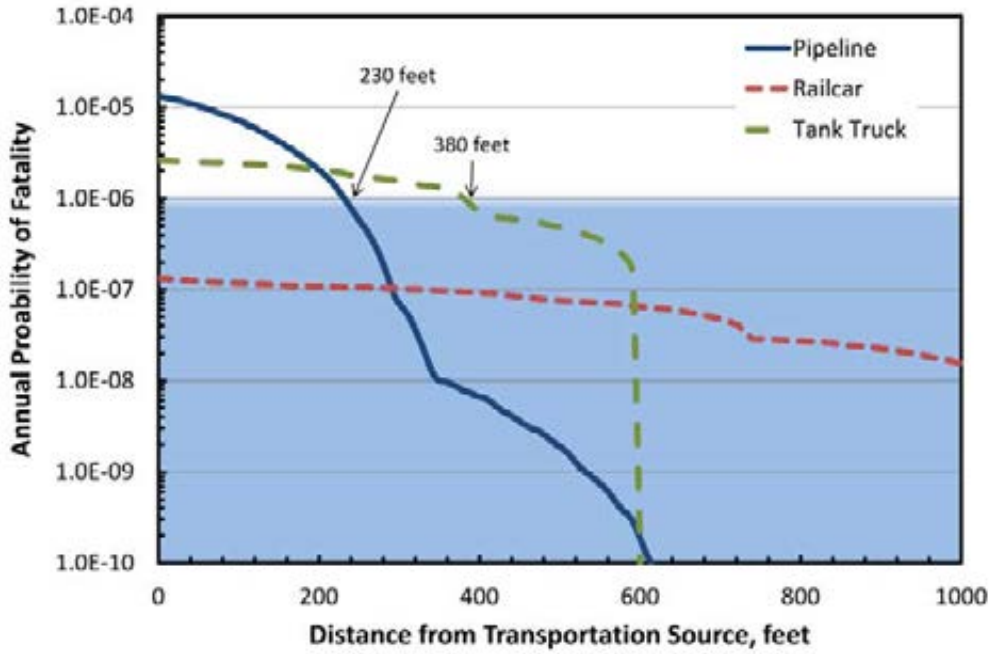

Figure 7-2
Risk Transects for the Finger Lakes Facility, 2012 Operating Projections

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7.4 Comparison to Other Risks

Another way to evaluate the risk imposed by the facility on the public is by using fatality rates from other activities or accidental events. Table 7-1 lists several potential causes of death (primarily things that the general public may be exposed to) in the form of odds of death in a one-year period and approximate annual probability of fatality. Table 7-1 is based on statistics for 2012, the latest year for which these values are available. The likelihood or frequency of fatality values presented are based on the total U.S. population for 2012 (306,803,000), and so represent the risk of fatality for the general population of this country. The exception to this is the entry for agricultural accidents: the population is based on agricultural workers, assuming each individual works 1,000 hours per year. Because of this the agricultural accident value is valid for agricultural workers only, not the general population.

Table 7-1
Odds of Early Fatality Data from the National Safety Council's *Injury Facts, 2014 Edition*

Cause of Death	Annual Number of Deaths in U.S. Population†	Odds of Death in a One-Year Period (one chance in…)	Approximate Annual Probability of Fatality
Cancer	574,743	534	1.87×10^{-3}
Motor vehicle accidents	35,332	8,683	1.15×10^{-4}
Accidental poisoning	33,041	9,286	1.08×10^{-4}
Agricultural accidents	450	9,616	1.04×10^{-4}
Falls	26,009	11,796	8.48×10^{-5}
Pedestrian (motor-vehicle accident)	5,457	56,222	1.78×10^{-5}
Releases from the Enterprise connection pipeline, assuming continuous annual occupancy directly above the pipeline	--	63,291	1.58×10^{-5}
Accidental choking	4,570	67,134	1.49×10^{-5}
Accidental drowning	3,782	81,122	1.23×10^{-5}
Exposure to smoke, fire, or flames	2,782	110,281	9.07×10^{-6}
Complications of medical/surgical care	2,490	123,214	8.12×10^{-6}
Exposure to forces of nature (heat, cold, storms, earthquakes, etc.)	1,342	228,616	4.37×10^{-6}
Releases from Finger Lakes LPG railcars, assuming continuous annual occupancy on the railroad	--	4,975,124	2.01×10^{-7}
Lightning	29	10,579,414	9.45×10^{-8}

† Population is the total 2012 population of the U.S.A., except for agricultural accidents; that statistic is based on the agricultural worker population

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An examination of Table 7-1 reveals that there are many potential causes of death (including agricultural accidents, motor vehicle accidents, falls, and accidental drowning) that have similar or higher probability of fatality, when compared to the risk of fatality imposed by the Finger Lakes LPG transportation activities in locations immediately adjacent to those transportation routes.

7.5 Study Conclusions

Quest Consultants Inc.® performed a quantitative risk analysis on the LPG transportation modes associated with the Finger Lakes LPG facility. The study was composed of four distinct tasks:

Task 1. Determine potential releases of LPG that could result in hazardous conditions for members of the public.
Task 2. For each potential release identified in Task 1, derive the annual probability of the release.
Task 3. For each potential release identified in Task 1, calculate the potentially lethal hazard zones.
Task 4. Using a consistent, accepted methodology, combine the probabilities from Task 2 with the potential release consequences from Task 3.

The first and third tasks, quantification of the hazards posed by the individual accidents, results in limiting the overall analysis to areas within about 1,050 feet of the LPG transportation routes. This was the maximum extent of a BLEVE of a loaded railcar. This failure is highly unlikely and should not be taken as characteristic of potential events associated with transportation of LPG. All other hazard zones (flammable gas, fire radiation, and explosion overpressure) were much smaller for all other potential accidents.

The second task, calculation of accident frequencies, relied on historical data available from the sources identified in Section 4.

The fourth task undertaken in this work was the calculation of risk posed to the public. The risk was quantified and presented in Section 6. Those results can be compared to generalized international acceptance criteria, as well as the probability of fatality for "everyday" causes, as discussed earlier in this section.

Based on a review of the information presented in this report, the following points can be made:

- A comparison of the risk posed by the three transportation modes shows that when the Finger Lakes LPG pipeline is used as a basis for transported volumes, movement of LPG by tank truck and railcar have somewhat higher risk than the pipeline, depending on an individual's location in relationship to the transportation route. If BLEVE events associated with tank trucks and railcars are omitted from the analysis, the risk for the road transportation modes is ten to one-hundred times less than the pipeline (given the fixed volume of product moved).
- The fatality risk associated with the Enterprise connection pipeline is approximately 1.5×10^{-5} per year (or one chance in 66,670 per year) at locations directly over the buried pipe, assuming continuous occupancy. The risk declines to zero at approximately 750 feet away from the pipeline route. The pipeline extends for less than a half mile, in an area where there are no residences and little potential public exposure. Annual exposure above 1.0×10^{-6} per year (or one chance in 1,000,000 per year) is only predicted for the area within about 250 feet of the pipeline, again assuming continuous occupancy.

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- This report presented two projections of the truck activity associated with the Finger Lakes LPG facility – the current market estimations, and the set of values presented in 2012. According to the current (2014) estimates, there will be no LPG tank trucks activity at the Finger Lakes LPG facility. This means that the incremental risk from the project associated with LPG trucking will be zero.
- Using the 2012 estimates for LPG truck activity associated with this project, the risk to the public, assuming continuous occupancy, is approximately 2.6 x 10^{-6} per year (one chance in 384,615 per year) on the roadway, declining to zero at approximately 600 feet away from the truck route. If the Finger Lakes LPG facility does load trucks, the associated risk will be distributed along Route 14 to the north and south of the facility. Most, if not all, of the truck activity from the facility (should it exist) is expected to displace truck activity leaving the Enterprise facility. Thus, even with the 2012 estimates, the incremental risk to the surrounding area due to LPG truck activity is expected to be negligible.
- For either the 2012 or current projections, the risk due to LPG railcar activity, assuming continuous occupancy, is predicted to be approximately 2.0 x 10^{-7} per year (or one chance in 5,000,000 per year) on the railway, declining to zero at approximately 1,100 feet away from the rail line. In all cases, the risk is imposed on the Schuyler County public only in the 12 miles of Norfolk-Southern track between the Finger Lakes LPG facility and the county line to the south.
- At all locations further than about 1,100, 750, or 600 feet away from a rail, pipeline, or tank truck LPG transportation route, respectively, risk to the public associated with LPG transportation accidents is zero.
- The most common international criterion for acceptability of risk posed on the public is exposure to a fatal hazard with a probability of 1.0 x 10^{-6} per year. This is equivalent to one chance in 1,000,000 per year of being fatally harmed by the hazardous material facility in question. By comparison with this criterion, all modes of transportation evaluated in this analysis are found to be acceptable when public occupancy is taken into account. In no case will a member of the public be present on a roadway, on the rail line, or above the pipeline for every minute of a given year. When an occupancy fraction is taken into account (for example, 3% of the year), the risk imposed by LPG transportation associated with the Finger Lakes LPG facility is clearly in the acceptable range by published international standards.
- When compared to other causes of death, the risk imposed by the Finger Lakes LPG transportation activities is also found to be minimal – approximately equal to being struck by lightning, if an individual is within about 1,000 feet of a transportation route for an entire year.

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8.0 REVIEW OF DR. MACKENZIE'S RISK ASSESSMENT

As a part of the risk analysis efforts presented in this report, Quest was also asked to review and comment on a report titled "*Independent High-Level Quantitative Risk Analysis: Schuyler County Liquid Propane Gas Storage Proposal,*" dated January 14, 2015, and authored by D. Rob Mackenzie, MD, FACHE of Trumansburg, New York. The report provides an evaluation of the potential consequences of LPG transportation and storage accidents, as well as estimates of the frequencies or probabilities of such events.

This review serves to demonstrate some of the shortcomings with the risk assessment.

8.1 Risk Analysis Qualifications

To properly assess the risk of hazardous materials, the analyst must adhere to certain methodologies established by process safety professionals. In addition, an education background in engineering or a related science/technology field is important if the properties of the hazardous materials are to be properly understood. To develop the knowledge about process safety and risk assessment that is necessary for this type of work, many years of experience are required.

Dr. Mackenzie is certainly experienced in the medical field and the specific risk assessment techniques applied in that profession. However, the risk assessment associated with processing and transportation of petrochemicals is a completely different field, requiring a different expertise. Dr. Mackenzie has not demonstrated that expertise, thus clouding the credibility and validity of his work on this subject.

8.2 Risk Analysis and Risk Assessment

The first concern with Dr. Mackenzie's report is that it titles itself a quantitative risk analysis (QRA). The Center for Chemical Process Safety (CCPS), a division of the American Institute of Chemical Engineers (AIChE), in its book "Guidelines for Chemical Transportation Risk Analysis" [CCPS, 2008] published the following definitions:

> Risk Analysis: *The process (qualitative or quantitative) of evaluating consequence and likelihood and estimating risk.*
>
> Risk Assessment: *The process by which the results of a risk analysis (for example, risk estimates) are used to make decisions, either through relative ranking of risk reduction strategies or through comparison with risk targets.*

A review of Dr. Mackenzie's work finds that the consequences of LPG transportation or storage events were addressed qualitatively, not quantitatively. The likelihood analysis presented in the report does use numbers, so may be construed to be quantitative. However, the values presented are based on information gathered about general industry trends, and are even labeled as "scores". There is a notable lack of specificity in his report when it comes to likelihood estimates and the outcomes of hazardous events that are possible. Consequently, the analysis presented by Dr. Mackenzie is not fully quantitative, and at best can only be labeled semi-quantitative.

Additionally, Dr. Mackenzie does not follow-through with risk reduction strategies or comparison with risk targets once he makes his risk estimates. Qualitative categorizations are simply followed with recommendations for further risk reduction or designation of the facility as unacceptably risky.

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8.3 Consequence Analysis

Dr. Mackenzie's approach to consequence analysis is severely limited. There is virtually no analysis of potential event sequences. For railroad events, there is discussion of the potential for derailment events with "leakage of fuel." The actual consequences are generalized statistics concerning a decade of railway incidents in the U.S., and some specific information about one incident in Italy. For pipelines, there is only a presentation of generalized statistics concerning a decade of pipeline incidents in the U.S. Neither of these presentations is specific to LPG transportation. When discussing potential salt cavern incidents, Dr. Mackenzie again presents some generalized information about the worst underground storage events that have occurred in the industry, without specifically addressing LPG.

Dr. Mackenzie's approach to the consequences of LPG transportation and storage events has several shortcomings:

- No consideration was given to a possible range of accident scenarios: everything that is presented is a major, or "doomsday" event. The potential for small or moderate accidents is not discussed.
- For rail car derailments (or LPG truck accidents), the possibility exists of no leak, a small leak, a pressure relief valve discharge, a moderate leak, a tank rupture, and other scenarios. To ignore these possibilities and assign all risk to one catastrophic event is a misrepresentation of reality.
- No consideration was given to the probability of ignition (or non-ignition) during an accident. In any accident scenario involving a flammable material, a conditional probability can be assigned to describe the likelihood of ignition. Releases which are ignited result in a fire that may impact the public. Unignited releases of LPG may cause no harm.
- There is no presentation of the extent of potential consequences, due to the lack of consequence modeling. The risk to the public is sensitive to the public's location, and LPG release events have limited ranges of influence.

Because of the factors listed above, Dr. Mackenzie's consequence analysis can only be described as qualitative, and in many ways is an exercise in guessing what consequences may follow a worst-case event.

8.4 Frequency Analysis

The frequency analysis provided by Dr. Mackenzie is roughly consistent throughout his report. The basis for frequency determination is more accurately described as a likelihood ranking, and is based on an arbitrary exposure interval of 25 years. While 25 years may be appropriate for occupational health (e.g., long-term exposure to a carcinogen), this type of basis is not used in a risk analysis which involves hazardous materials such as LPG.

In a QRA for a petrochemical process, storage, or transportation system, the basis of risk analysis frequencies are defined as annual. Equipment failure rates are expressed on a per-year basis. Transportation accidents are expressed on an annual basis. Criteria for tolerability or acceptability of risk to the public are always based on the probability of a yearly (annual) exposure. Thus, all frequency values within a QRA are put in terms based on one year. This allows a common time period of measure, and allows comparison to other risks that a population may be exposed to. For example, in this QRA report, a comparison table (Table 7-1) was provided to compare the likelihood of early fatality, based on data from the National Safety Council's *Injury Facts, 2014* publication, for events such as accidental choking, agricultural accidents, lightning, and motor vehicle accidents. The annual risks due to a hazardous materials facility can then be compared to these values to enable an assessment of the risk associated with the facility's activities.

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8.4.1 LPG Rail Car Accidents

Dr. Mackenzie presents a rail car event frequency, for all "serious" accidents, of about 9.2 x 10^{-4} per year (equivalent to about one chance in 1,085 per year). This is based on the 12 miles of track in Schuyler County, a generic value of 1.6 x 10^{-6} derailments per mile, a conditional probability of 0.2 overturning events per derailment, and 150 train trips per year for the Finger Lakes LPG facility. No mention is made of the probability that rail cars do not release, or experience a small release of, their contents in an overturning accident.

The rail car release event frequency applied in this (Quest's) transportation QRA is based on:

- 2.02 x 10^{-8} releases per railcar-mile, specifically for LPG (or similar) rail cars
- 12 miles of track in Schuyler county
- 1,785 loaded rail cars per year arriving or departing the facility (this includes propane and butane loads, and ignores empty rail cars)

These values result in a total rail car release event frequency of 4.3 x 10^{-4} per year (or one chance in 2,325 per year) for the Finger Lakes LPG terminal. If this value is constrained to major releases and catastrophic events (removing leaks and small events) the "serious" rail car event frequency is found to be 2.48 x 10^{-5} per year (or one chance in 40,335 per year). This is about 2.7% of Dr. Mackenzie's value.

(Note that event frequencies describe a range of possible outcomes, do not account for ignition vs. non-ignition, do not account for weather conditions, and do not incorporate the consequences of an event. Thus, they are not a description of risk, nor are they to be compared with the risk analysis results presented in Sections 6 and 7 of this report.)

8.4.2 LPG Pipeline Releases

In his risk assessment report, Dr. Mackenzie presents statistics for "significant" pipeline incidents, as extracted from the Pipeline and Hazardous Material Safety Administration (PHMSA) database. In a ten-year period, he states that there were 278 significant incidents over the 63,000 miles of liquids pipelines network. This, combined with 21 miles of existing LPG pipeline in Schuyler County, results in an incident frequency of 9.27 x 10^{-3} per year (or a chance of 1 in 108 per year).

The pipeline release frequency applied in this (Quest's) transportation QRA is based on:

- 1.57 x 10^{-3} releases per mile of pipeline per year, based on the PHMSA hazardous liquids pipeline database
- 0.5 miles of newly installed LPG pipeline, that associated with the Finger Lakes LPG terminal

These values result in a total pipeline release frequency of 7.85 x 10^{-4} per year (or one chance in 1,275 per year) for the Finger Lakes LPG facility. If this value is constrained to major and rupture events (removing punctures and leaks) the "significant" pipeline event frequency is found to be 4.875 x 10^{-4} per year (or one chance in 2,090 per year). This is about 5.2% of Dr. Mackenzie's value primarily due to his inclusion of the 21 miles of existing Schuyler County LPG pipeline.

8.4.3 Underground LPG Storage Incidents

In a report published by the Gas Processors Associates [GPA, 2002], underground storage data for the year 2001 is presented (this is the last known year for which this type of survey was done). The report

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provides a listing of the U.S. and Canadian underground storage sites by state, operating company, storage type, and product type. The data show that there are at least 700 bedded salt formation caverns holding LPG/NGL in the U.S. A total of over 1,100 underground LPG storage caverns are found when salt domes and underground storage in Canada are included. More caverns have been placed into service since the GPA report, but no reliable information is available on the exact count of caverns.

In a separate data set derived from the GPA report, data concerning underground storage in the state of Texas was provided. This data includes the year the cavern was mined or established. From that data subset, the average age of all Texas caverns is about 45 years (from the date drilled until now).

An evaluation of the incidents involving NGL/LPG storage in salt formation, in the U.S. and Canada, from multiple sources [Evans, 2007] [Hopper, 2004] [Warren, 2015] shows that over the past 45 years, there were 3 incidents involving fatalities or injuries. There were an additional 7 (approximately) that involved evacuations and/or on-site property damage; these types of events, although sensational, did not result in injury or fatality to the public. Using the above information, a rough estimate of salt cavern failure frequency can be developed:

- About 1,125 NGL/LPG salt caverns in service
- An assumed 45 years of service per cavern
- About 3 major incidents involving NGL/LPG salt caverns present a public risk of fatality/injury

With these three parameters, a major incident frequency of 5.93×10^{-5} per year (or one chance 16,875 per year) per cavern is calculated. If applied to the Finger Lakes LPG terminal's 2 LPG caverns, a major incident frequency of 1.19×10^{-4} per year is calculated (one chance in 8,405 per year).

In Quest's 2012 report a value of 1.0×10^{-5} per year for catastrophic cavern failures releasing to atmosphere was presented. This value was based on information from a report published by the U.K.'s Health and Safety Executive [HSE, 2008]. In that report (RR671), a value of 4.0×10^{-5} per year per cavern, for all types of cavern failures, is presented. However, the report states that this value integrates surface equipment failures into that number. Because Quest's 2012 QRA independently accounted for failures of surface equipment by applying published standard equipment failure rates, the catastrophic cavern failure frequency that was applied in that analysis was lower than the HSE value.

The HSE value for cavern failures correlates well with the number calculated above. These values are in the proper range for such events, which would be characterized as low frequency, high consequence scenarios. Comparing Dr. Mackenzie's calculations for cavern failures reveals several discrepancies with the numbers presented above. He claims that there are 30 salt cavern fuel storage facilities in the U.S., and from those, within the past 40+ years, there are "at least 20 serious or extremely serious incidents." This leads to a reported major event frequency of 1.6% per year (1.6×10^{-2} per year, or one in 60 per year) per facility. This value is 100 to 1,000 times higher than the values presented above, for several reasons:

- The calculation is based on the number of facilities with underground salt cavern storage, not the number of caverns. Some facilities have over 100 caverns, some have 1. Dr. Mackenzie's report even states that "Regarding incremental risk, there also appears to be a direct correlation between the number of salt caverns used for storage per facility and the likelihood of serious and extremely serious events." The Finger Lakes LPG facility will use 2 caverns, much less than many of the facilities in the U.S. (the average U.S. or Canadian facility has about 10 caverns).
- The presented number of facilities is quoted from a British Geological Survey report's Table 2 [Evans, 2007], which seems to be for underground natural gas storage, not NGL/LPG storage.

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- Dr. Mackenzie's count of incidents appears to include (the presentation is not clear on this issue) events involving underground oil storage and underground natural gas storage, not just NGL/LPG. The events count also appears to include incidents that occurred outside of the U.S.

Because of these discrepancies, the cavern failure rate presented in Dr. Mackenzie's report cannot be reliably used for addressing the risk of storing LPG in salt caverns, and is in some ways simply incorrect. A better representation is as presented in the previous section, which is consistent with the value presented in the 2008 HSE report.

8.4.4 Comparison

Dr. Mackenzie presents his risk assessment in the form of a risk matrix. On the likelihood, or frequency, side of the matrix are categories that are defined as:

- Very low – less than 0.1% per year (less than one chance in 1,000 per year)
- Low – between 0.1% and 1% per year (between one chance in 1,000 and one chance in 100 per year)
- Medium – 5% to 20% per year (somewhere between one chance in 20 per year and one chance in 5 per year)
- High, very high – undefined; these categories not used or defined in the analysis

A review of the major event frequencies that are applied in Quest's QRA work, with specific application to the Finger Lakes LPG facility, finds that major LPG rail car releases (2.48×10^{-5} per year) would be classified in the "very low" category. Major LPG pipeline releases (4.875×10^{-4} per year) and major salt cavern failures (1.19×10^{-4} per year) would all fall into the "low" category.

8.5 Watkins Glen Gorge Accidents

One of the more sensitive issues raised in Dr. Mackenzie's report is the potential consequences associated with an LPG railcar accident over the Watkins Glen Gorge. The LPG railcars arriving at and departing the Finger Lakes facility will travel on the rail line that passes over the gorge. The railroad bridge is approximately 75 feet above the bottom of the gorge at its deepest section. The railroad bridge is approximately 0.1 mile long.

The discussion presented in Section 4.1.2 of this report calculated a rate of accident and release from LPG railcars. This rate was constrained to those events which released products in the 29121 STCC group. By returning to the PHMSA database [PHMSA, 2014] a derailment rate for LPG railcars can be derived. The PHMSA database was searched for all derailment events involving 29121 STCC products between and including 2000 to 2012; the total of miles traveled in those years from the STB was defined in Section 4 of this report. This results in an LPG rail car derailment rate of 2.73×10^{-8} per railcar-mile, or one chance of derailment in 36,630,000 per year per railcar.

By application of the distance traveled over the gorge and the number of railcars per year, a derailment rate for Finger Lakes LPG railcars as they pass over Watkins Glen Gorge can be calculated. The resulting probability, based on 1,785 loaded railcars per year, is 4.87×10^{-6} derailments per year, or one chance in about 205,000 per year.

If a derailment happens over the Watkins Glen Gorge, the consequences are expected to be severe. An LPG railcar's fall into the gorge will likely result in catastrophic failure of a railcar, with immediate ignition of the released contents due to the nature of the event. The outcome is a fireball, similar to the

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BLEVE events modeled in the QRA study. In rare events, a railcar could fall into the gorge and fail without ignition. The result would be a flammable gas cloud that slowly travels downhill (following Glen Creek) and is dispersed by wind moving through the gorge as well as by passive dispersion. It is unlikely that a flammable mixture will be able to travel the 1.1 miles from the railroad bridge to the town of Watkins Glen, especially without being ignited. So while the hazards in the gorge due to this unlikely event could be severe, there is little risk to the town of Watkins Glen. In addition, this accident is possible today, as there are already LPG railcar movements on the Norfolk-Southern railway over the gorge.

8.6 Risk Basis

One of the more notable problems with Dr. Mackenzie's risk assessment is that it does not fully evaluate any similar, existing risk in the Schuyler County area. The assessment does introduce the concept of overall and incremental risk. However, there is no presentation of a risk ranking for the existing risk in order to properly compare and evaluate the incremental risk. The analysis simply assigns risk classifications to LPG rail transportation, LPG pipeline, and salt cavern LPG storage activities associated with the Finger Lakes LPG facility. The presence of similar risk sources in the county today includes:

- LPG truck activity already exists; there is an extensive network of LPG supply facilities and fleet of delivery trucks that provide LPG for home heating for many county residents. (Dr. Mackenzie's work does not address the potential LPG trucking aspect of the project due to the current projection that there will be no LPG truck traffic associated with the facility.)
- The rail line through Schuyler County exists; it is unknown how many tank cars carrying hazardous materials are transported through the county, but it is expected that the LPG hazards (the consequences) described by Dr. Mackenzie are present today.
- The area already has many salt caverns that are used for solution mining, LPG storage, and natural gas storage; the hazards associated with salt caverns, and to some extent, brine spills, exist now.
- There is a major (8-inch diameter) LPG pipeline passing through Schuyler County; this pipeline transports LPG to/from out-of-state sources, existing local facilities, and other portions of New York.

Thus, a complete evaluation of the incremental risk to the Schuyler County area due to the addition of the Finger Lakes LPG facility would begin with a baseline evaluation and risk ranking of similar activities in the county that exist now. Because some level of risk from similar sources is present now, it can be inferred that the existing risks are acceptable, or at least tolerated in the county.

As with Quest's risk assessment results (presented in Section 7 of this report), there is likely insufficient data on which to base a quantitative comparison of the baseline risk and the risk added by the Finger Lakes LPG facility. However, even with Dr. Mackenzie's qualitative work, a risk ranking of present risk compared to incremental (future) risk is possible. If the addition of the Finger Lakes facility can be shown to raise the existing level of risk in a significant way, then perhaps Dr. Mackenzie's conclusions have some merit (ignoring, for the sake of this argument, the validity of his methodology). But if the additional risk posed by the Finger Lakes facility only marginally affects the existing risk, it would be difficult to argue that the facility raises the overall risk to an unacceptable level.

8.7 Summary

The qualitative risk assessment provided by Dr. Mackenzie includes the two elements of risk – consequence and probability – for LPG transportation and storage systems. He presents these elements in

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a risk matrix in order to define the risk imposed on the public. The application of a risk matrix can be useful when risk reduction measures are being discussed and prioritized. However, there are several significant shortcomings of Dr. Mackenzie's risk assessment, as identified by this review:

- While Dr. Mackenzie may be well-qualified for risk assessment in the medical field, his experience does not translate well into petrochemical systems risk. His risk assessment of the Finger Lakes LPG facility fails to address some of the specific possibilities (both in consequence and frequency) of LPG systems accident scenarios.
- The risk assessment focuses its attention on events that, while possible, are part of the low frequency, high consequence set of scenarios that define the outer extent of public risk. These events, while spectacular, generally do not significantly affect public risk. As outlined in this report, for every accident scenario, there are many possible event outcomes that are less consequential than the ones suggested by Dr. Mackenzie, or where mitigation measures may be effective in preventing or eliminating impacts to the public.
- The risk assessment applies event likelihoods that are developed from generic sources or that apply to systems outside the scope of the LPG systems which will be part of Finger Lakes LPG. The result is event likelihoods that are inappropriate for this application and often too large.
- The risk assessment does not properly account for the risk as it exists in the county today. The existing risk (which can be implicitly viewed as acceptable), includes an LPG pipeline, LPG truck activity, hazardous material railcar movements, and existing salt cavern risks associated with storage of LPG, storage of natural gas, and storage/movements of brine. A proper incremental risk assessment would compare the existing risk to the future risk following commencement of operations at the Finger Lakes LPG facility.
- A proper assessment of public risk will consider a wide range of possible event outcomes and their respective probabilities in order to recommend risk reduction measures or to compare to defined risk targets. Dr. Mackenzie's risk assessment fails to do this by considering only worst-case events coupled with overly conservative estimates for likelihoods and not comparing the results to a risk target.

Thus, for the above reasons, Dr. Mackenzie's risk assessment conclusions are effectively an overprediction the potential risk to the public in Schulyer County. The use of a risk matrix is common in the process safety business, and is a useful tool for prioritizing risk reduction measures. Risk matrices are inherently subjective (thus the qualitative nature) because the consequences and frequencies are placed into categories by the analyst. Dr. Mackenzie's assessment, or at least the methodology applied in his assessment, may have some value in emergency planning or mitigation prioritization, but does not present a balanced approach to the actual risks posed to Schuyler County residents by the Finger Lakes LPG facility. While Dr. Mackenzie does provide a risk assessment (the step following a risk analysis), a proper, comparative quantitative risk analysis was not conducted. The shortcomings in Dr. Mackenzie's analysis and lack of development of risk measures give an end result that has little to no value in determining the acceptability of the Finger Lakes LPG facility.

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APPENDIX A
CANARY BY QUEST® MODEL DESCRIPTIONS

The following model descriptions are taken from the CANARY by Quest® User Manual.

Section A	Engineering Properties
Section C	Torch Fire and Flare Radiation Model
Section D	Fireball Model
Section E	Fluid Release Model
Section F	Momentum Jet Dispersion Model
	QMEFS Vapor Cloud Explosion Model

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Engineering Properties

Purpose

The purpose of this model is to provide an accurate means of computing physical and thermodynamic properties of a wide range of chemical mixtures and pure components using a minimum of initial information.

Required Data

(a) Fluid composition
(b) Temperature and pressure of the fluid prior to release

Methodology

Basic thermodynamic properties are computed using the Peng-Robinson equation of state [Peng and Robinson, 1976]. The necessary physical and thermodynamic properties are calculated in the following manner.

Step 1: The temperature and pressure of the fluid at storage conditions and the identity and mole fraction of each component of the fluid are obtained. Mixture parameters are determined using data from the extensive properties data base within CANARY.

Step 2: Each calculation begins with the computation of the vapor and liquid fluid composition. For cases where the temperature and pressure result in only one phase being present, the vapor or liquid composition will be the same as the initial feed composition. The composition calculation is an iterative procedure using a modification of the techniques described by Starling [1973].

Step 3: Once the vapor and liquid compositions are known, the vapor and liquid densities, enthalpies, entropies, and heat capacities can be computed directly. Other physical properties (viscosity, thermal conductivity, surface tension, etc.) are computed using correlations developed in Reid, Prausnitz, and Poling [1987].

Step 4: A matrix of properties is computed over a range of temperatures and pressures. Physical and thermodynamics properties required by other models within CANARY are then interpolated from this table.

Basic Thermodynamic Equations

$$Z^3 - (1-B) \bullet Z^2 + \left(A - 3 \bullet B^2 - 2 \bullet B\right) \bullet Z - \left(A \bullet B - B^2 - B^3\right) = 0 \qquad (1)$$

where: Z = fluid compressibility factor, $\frac{P \bullet V}{R \bullet T}$, dimensionless

P = system pressure, kPa

V = fluid specific volume, m^3/kmol

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R = gas constant, 8.314 $m^3 \bullet$ kPa/(kmol $\bullet$ K)
T = absolute temperature, K

$$A = \frac{a \bullet P}{R^2 \bullet T^2}$$

$$a = 0.45724 \bullet \frac{R^2 \bullet T^2}{P_c} \bullet \alpha$$

$$\alpha = \left[1 + m \bullet \left(1 - T_r^{0.5}\right)^2\right]$$

$$m = 0.37464 + 1.54226 \bullet \omega - 0.26992 \bullet \omega^2$$

ω = acentric factor

$$T_r = \frac{T}{T_c}$$

T_c = pseudo-critical temperature, K
P_c = pseudo-critical pressure, kPa

$$B = \frac{b \bullet P}{R \bullet T}$$

$$b = 0.0778 \bullet R \bullet \frac{T_c}{P_c}$$

$$H = H^o + \frac{P}{\rho} - R \bullet T + \int_0^{\rho} \left[P - T \bullet \left(\frac{\partial P}{\partial T}\right)_{\rho}\right] \bullet \left(\frac{d\rho}{\rho^2}\right) \tag{2}$$

where: H = enthalpy of fluid at system conditions, kJ/kg
H^o = enthalpy of ideal gas at system temperature, kJ/kg

$$S = S^o - R \bullet \ln\left(\rho \bullet R \bullet T\right) + \int_0^{\rho} \left[\rho \bullet R - \left(\frac{\partial P}{\partial T}\right)_{\rho}\right] \bullet \left(\frac{d\rho}{\rho^2}\right) \tag{3}$$

where: S = entropy of fluid at system conditions, kJ/(kg $\bullet$ K)
S^o = entropy of ideal gas at system temperature, kJ/(kg $\bullet$ K)

$$R \bullet T \bullet \ln\left(\frac{f_i}{f_i^o}\right) = \left[\left(H_i - H_i^o\right) - T \bullet \left(S_i - S_i^o\right)\right] \tag{4}$$

where: f_i = fugacity of component i, kPa
f_i^o = standard state reference fugacity, kPa

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Torch Fire and Flare Radiation Model

Purpose

The purpose of this model is to predict the impact of fire radiation emitted by burning jets of vapor. Specifically, the model predicts the maximum radiant heat flux incident upon a target as a function of distance between the target and the point of release.

Required Data

(a) Composition of the released material
(b) Temperature and pressure of the material before release
(c) Mass flow rate of the material being released
(d) Diameter of the exit hole
(e) Wind speed
(f) Air temperature
(g) Relative humidity
(h) Elevation of the target (relative to grade)
(i) Elevation of the point of release (relative to grade)
(j) Angle of the release (relative to horizontal)

Methodology

Step 1: A correlation based on a Momentum Jet Model is used to determine the length of the flame. This correlation accounts for the effects of:

- composition of the released material,
- diameter of the exit hole,
- release rate,
- release velocity, and
- wind speed.

Step 2: To determine the behavior of the flame, the model uses a momentum-based approach that considers increasing plume buoyancy along the flame and the bending force of the wind. The following equations are used to determine the path of the centerline of the flame [Cook, et al., 1987].

$$\Phi_X = (\rho_{ja})^{0.5} \bullet \bar{u} \bullet \sin(\theta) \bullet \cos(\varphi) + (\rho_\infty)^{0.5} \bullet u_\infty \qquad \text{(downwind)}$$

$$\Phi_Y = (\rho_{ja})^{0.5} \bullet \bar{u} \bullet \sin(\theta) \bullet \sin(\varphi) \qquad \text{(crosswind)}$$

$$\Phi_Z = (\rho_{ja})^{0.5} \bullet \bar{u} \bullet \cos(\theta) + (\rho_\infty)^{0.5} \bullet u_b \bullet \frac{(i+1)}{n} \qquad \text{(vertical)}$$

where: Φ_{XYZ} = momentum flux in X, Y, Z direction
ρ_{ja} = density of the jet fluid at ambient conditions, kg/m^3

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$\bar{u}$ = average axial velocity of the flame, m/s
θ = release angle in $X-Z$ plane (relative to horizontal), degrees
φ = release angle in $X-Y$ plane (relative to downwind), degrees
ρ_∞ = density of air, kg/m^3
u_∞ = wind speed, m/s
ρ_b = density of combustion products, kg/m^3
u_b = buoyancy velocity, m/s
n = number of points taken along the flame length

These correlations were developed to predict the path of a torch flame when released at various orientations. The model currently does not allow a release angle in a crosswind direction; the release angle is confined to the downwind/vertical plane (i.e., $\varphi = 0$).

Step 3: The angle of flame tilt is defined as the inclination of a straight line between the point of release and the end point of the flame centerline path (as determined in Step 2).

Step 4: The geometric shape of the flame is defined as a frustum of a cone (as suggested by several flare/fire researchers [e.g., Kalghatgi, 1983, Chamberlain, 1987]), but modified by adding a hemisphere to the large end of the frustum. The small end of the frustum is positioned at the point of release, and the centerline of the frustum is inclined at the angle determined in Step 3.

Step 5: The surface emissive power is determined from the molecular weight and heat of combustion of the burning material, the release rate and velocity, and the surface area of the flame.

Step 6: The surface of the flame is divided into numerous differential areas. The following equation is then used to calculate the view factor from a differential target, at a specific location outside the flame, to each differential area on the surface of the flame.

$$F_{dA_t \to dA_f} = \frac{\cos(\beta_t) \bullet \cos(\beta_f)}{\pi \bullet r^2} \bullet dA_f \qquad \text{for } [\beta_t] \text{ and } [\beta_f] < 90°$$

where: $F_{dA_t \to dA_f}$ = view factor from a differential area on the target to a differential area on the surface of the flame, dimensionless
dA_f = differential area on the flame surface, m^2
dA_t = differential area on the target surface, m^2
r = distance between differential areas dA_t and dA_f, m
β_t = angle between normal to dA_t and the line from dA_t to dA_f, degrees
β_f = angle between normal to dA_f and the line from dA_t to dA_f, degrees

Step 7: The radiant heat flux incident upon the target is computed by multiplying the view factor for each differential area on the flame by the surface missive power and by the appropriate atmospheric transmittance, then summing these values over the surface of the flame.

$$q_{ai} = \sum_{A_f} q_{sf} \bullet F_{dA_t \to dA_f} \bullet \tau$$

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where: q_{ai} = attenuated radiant heat flux incident upon the target due to radiant heat emitted by the flame, kW/m^2

A_f = area of the surface of the flame

q_{sf} = radiant heat flux emitted by the surface of the flame, kW/m^2

τ = atmospheric transmittance, dimensionless

Atmospheric transmittance, τ, is a function of absolute humidity and r, the path length between differential areas on the flame and target [Wayne, 1991].

Step 8: Steps 6 and 7 are repeated for numerous target locations.

Validation

Several of the equations used in the Torch Fire and Flare Radiation Model are empirical relationships based on data from medium- to large-scale experiments, which ensures reasonably good agreement between model predictions and experimental data for variables such as flame tilt angle. Comparisons of experimental data and model predictions for incident heat flux at specific locations are more meaningful and of greater interest. Unfortunately, few reports on medium- or large-scale experiments contain the level of detail required to make such comparisons.

One reasonable source of test data is a report by Chamberlain [1987]. It contains data from seven flare tests involving natural gas releases from industrial flares, with several data points being reported for each test. Variables that were examined during these tests include release diameter (0.203 and 1.07 m), release rate and velocity, and wind speed. Figure C-1 compares the predicted values of incident heat flux with experimental data from the seven flare tests.

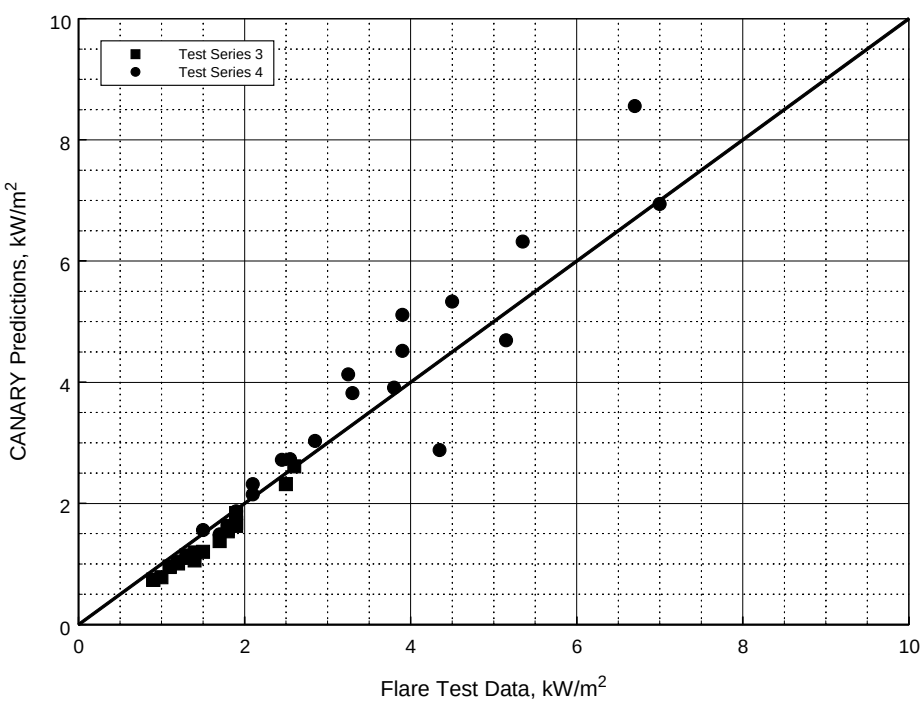

Figure C-1

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Fireball Model

Purpose

The purpose of the Fireball Model is to predict the impact of thermal radiation emitted by fireballs that result from catastrophic failures of pressure vessels containing superheated liquids. Specifically, the model predicts the average radiant heat flux incident upon a grade-level target as a function of the horizontal distance between the target and the center of the fireball.

Required Data

(a) Composition of flammable liquid within the pressure vessel
(b) Mass of flammable liquid within the pressure vessel
(c) Pressure within vessel just prior to rupture
(d) Temperature of the liquid within the vessel just prior to rupture
(e) Air temperature
(f) Relative humidity

Methodology

Step 1: Calculate the mass of fuel consumed in the fireball. The mass of fuel in the fireball is equal to the smaller of the mass of fuel in the vessel (as specified by the user), or three times the mass of fuel that flashes to vapor when it is released to the atmosphere [Hasegawa and Sato, 1977].

Step 2: Calculate the maximum diameter of the fireball using the empirical correlation from Roberts [1981/82].

$$D_{\max} = 5.8 \bullet M_f^{1/3}$$

where: $D_{\max}$ = maximum diameter of the fireball, m
M_f = mass of fuel in the fireball, kg

Step 3: Calculate fireball duration using the following empirical correlation [Martinsen and Marx, 1999].

$$t_d = 0.9 \bullet M_f^{1/4}$$

where: t_d = fireball duration, s
M_f = mass of fuel in the fireball, kg

Step 4: Calculate the size of the fireball and its location, as a function of time. The fireball is assumed to grow at a rate that is proportional to the cube root of time, reaching its maximum diameter, $D_{\max}$, at the time of liftoff, $t_d/3$. During its growth phase, the fireball remains tangent to grade. After liftoff, it rises at a constant rate [Shield, 1994].

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Step 5: Estimate the surface flux of the fireball. The fraction of the total available heat energy that is emitted as radiation is calculated using the equation derived by Roberts [1981/82].

$$f = 0.0296 \bullet P^{0.32}$$

where: f = fraction of available heat energy released as radiation, dimensionless
P = pressure in vessel at time of rupture, kPa

The total amount of energy emitted as radiation is then calculated.

$$E_r = f \bullet M_f \bullet \Delta H_c$$

where: E_r = energy emitted as radiation, kJ
ΔH_c = heat of combustion, kJ/kg

The surface flux is estimated by dividing E_r by the average surface area of the fireball and the fireball duration, but it is not allowed to exceed 400 kW/m^2.

Step 6: Calculate the maximum view factor from a differential target (at specific grade level locations outside the fireball) to the fireball, using the simple equation for a spherical radiator [Howell, 1982].

$$F = \frac{R^2}{H^2}$$

where: F = view factor from differential area to the fireball, dimensionless
R = radius of the fireball, m
H = distance between target and the center of the fireball, m

R and H vary with time due to the growth and rise of the fireball. Therefore, the duration of the fireball is divided into time intervals and a view factor is calculated at the end of each interval.

Step 7: Compute the attenuated radiant heat flux at each target location, at the end of each time interval, by multiplying the appropriate view factor by the surface flux of the fireball and by the appropriate atmospheric transmittance. The transmittance of the atmosphere is a function of the absolute humidity and path length from the fireball to the target [Wayne, 1991]. For each target location, calculate the average attenuated heat flux over the duration of the fireball.

Step 8: Calculate the absorbed energy at each target location. For a given location, the energy absorbed during each time interval is computed by multiplying the length of the interval by the average attenuated radiant heat flux for that interval. The absorbed energies for all time intervals are then summed to determine the radiant energy absorbed over the duration of the fireball.

Step 9: Calculate the integrated dosage at each target location. This is computed in the same manner as absorbed energy is computed in Step 8, except that the average attenuated radiant heat flux for each time interval is taken to the 4/3rds power before it is multiplied by the time interval. This allows the dosage to be used in the probit equation for fatalities from thermal radiation [Eisenberg, Lynch, and Breeding, 1975].

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$$Pr = -38.4785 + 2.56 \bullet \ln\left(q^{4/3} \bullet t\right)$$

where: Pr = probit
q = radiant heat flux, W/m^2
t = exposure time, s

Validation

Several of the equations used in the Fireball Model are empirical relationships based on data from small- to medium-scale experiments, which ensures reasonably good agreement between model predictions and experimental data for variables such as maximum fireball diameter. Comparisons of experimental data and model predictions for average incident heat flux, absorbed energy, or dosage are more meaningful and of greater interest. Unfortunately, very few reports on small- or medium-scale fireball experiments contain the level of detail required to make such comparisons, and no such data are available for large-scale experiments.

One of the most complete sources of test data for medium-scale fireball tests is a report by Johnson, Pritchard, and Wickens [1990]. It contains data on five BLEVE tests that involved butane and propane, in quantities up to 2,000 kg. Figure D-1 compares the predicted values of absorbed energy with experimental data from those five BLEVE tests.

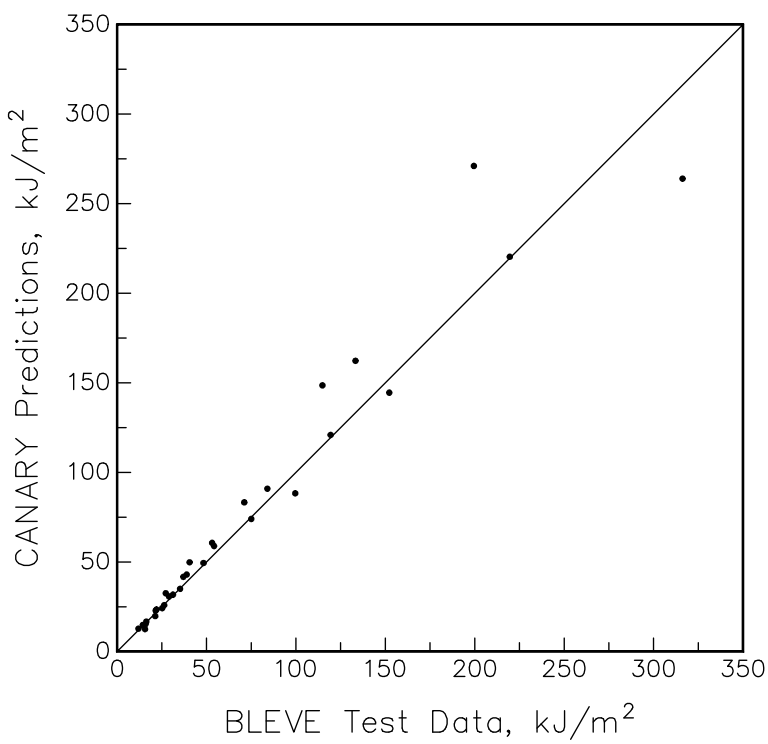

Figure D-1

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Fluid Release Model

Purpose

The purpose of the Fluid Release Model is to predict the rate of mass release from a breach of containment. Specifically, the model predicts the rate of flow and the physical state (liquid, two-phase, or gas) of the release of a fluid stream as it enters the atmosphere from a circular breach in a pipe or vessel wall. The model also computes the amount of vapor and aerosol produced and the rate at which liquid reaches the ground.

Required Data

(a) Composition of the fluid
(b) Temperature and pressure of the fluid just prior to the time of the breach
(c) Normal flow rate of fluid into the vessel or in the pipe
(d) Size of the pipe and/or vessel
(e) Length of pipe
(f) Area of the breach
(g) Angle of release relative to horizontal
(h) Elevation of release point above grade

Methodology

Step 1: Calculation of Initial Flow Conditions

The initial conditions (before the breach occurs) in the piping and/or vessel are determined from the input data, coupled with a calculation to determine the initial pressure profile in the piping. The pressure profile is computed by dividing the pipe into small incremental lengths and computing the flow conditions stepwise from the vessel to the breach point. As the flow conditions are computed, the time required for a sonic wave to traverse each section is also computed. The flow in any length increment can be all vapor, all liquid, or two-phase (this implies that the sonic velocity within each section may vary). As flow conditions are computed in each length increment, checks are made to determine if the fluid velocity has exceeded the sonic velocity or if the pressure in the flow increment has reached atmospheric. If either condition has been reached, an error code is generated and computations are stopped.

Step 2: Initial Unsteady State Flow Calculations

When a breach occurs in a system with piping, a disturbance in flow and pressure propagates from the breach point at the local sonic velocity of the fluid. During the time required for the disturbance to reach the upstream end of the piping, a period of highly unsteady flow occurs. The portion of the piping that has experienced the passage of the pressure disturbance is in accelerated flow, while the portion upstream of the disturbance is in the same flow regime as before the breach occurred.

To compute the flow rate from the breach during the initial unsteady flow period, a small time increment is selected and the distance that the pressure disturbance has moved in that time increment is computed using the sonic velocity profile found in the initial pressure profile calculation. The

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disturbed length is subdivided into small increments for use in an iterative pressure balance calculation. A pressure balance is achieved when a breach pressure is found that balances the flow from the breach and the flow in the disturbed section of piping. Another time increment is added, and the iterative procedure continues. The unsteady period continues until the pressure disturbance reaches the upstream end of the pipe.

Step 3: Long-Term Unsteady State Flow Calculations

The long-term unsteady state flow calculations are characterized by flow in the piping system that is changing more slowly than during the initial unsteady state calculations. The length of accelerated flow in the piping is constant, set by the user input pipe length. The vessel contents are being depleted, resulting in a potential lowering of pressure in the vessel. As with the other flow calculations, the time is incremented and the vessel conditions are computed. The new vessel conditions serve as input for the pressure drop calculations in the pipe. When a breach pressure is computed that balances the breach flow with the flow in the piping, a solution for that time is achieved. The solution continues until the ending time or other ending conditions are reached.

The frictional losses in the piping system are computed using the equation:

$$h = \left(\frac{4 \bullet f \bullet L \bullet U_{ls}^2}{2 \bullet g_c \bullet D_e} \right) \tag{1}$$

where: h = head (pressure) loss, ft of fluid
f = friction factor
L = length of system, ft
U = average flowing velocity, ft/sec
g_c = gravitational constant, 32.2 $lb_m \bullet ft/(lb_f \bullet sec^2)$
D_e = equivalent diameter of duct, ft

The friction factor is computed using the following equation:

$$\frac{1}{\sqrt{f}} = 1.74 - 2.0 \bullet \log_{10} \left[\frac{2 \bullet \varepsilon}{D_e} + \frac{18.7}{Re \bullet \sqrt{f}} \right] \tag{2}$$

where: ε = pipe roughness, ft
Re = Reynolds number, $D_e \bullet U \bullet \rho / \mu$, dimensionless
ρ = fluid density, lb/ft^3
μ = fluid viscosity, $lb/(ft \bullet sec)$

Equations (1) and (2) are used for liquid, vapor, and two-phase flow regimes. Since the piping is subdivided into small lengths, changes in velocity and physical properties across each segment are assumed to be negligible. At each step in the calculation, a check is made to determine if the fluid velocity has reached or exceeded the computed critical (sonic) velocity for the fluid. If the critical velocity has been exceeded, the velocity is constrained to the critical velocity and the maximum mass flow rate in the piping has been set.

If the fluid in the piping is in two-phase flow, the Lockhart and Martinelli [1949] modification to Equation (1) is used. The Lockhart and Martinelli equation for head loss is shown below:

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$$h_{TP} = \Phi^2 \bullet \left(\frac{4 \bullet f \bullet L \bullet U_{ls}^2}{2 \bullet g_c \bullet D_e} \right) \tag{3}$$

where: h_{TP} = head loss for two-phase flow, ft of fluid
Φ = empirical parameter correlating single- and two-phase flow, dimensionless
U_{ls} = superficial liquid velocity (velocity of liquid if liquid filled the pipe), ft/sec

This equation is valid over short distances where the flowing velocity does not change appreciably.

Validation

Validation of fluid flow models is difficult since little data are available for comparison. Fletcher [1983] presented a set of data for flashing CFC-11 flowing through orifices and piping. Figures E-1 through E-4 compare calculations made using the Fluid Release Model with the data presented by Fletcher. Figure E-1 compares fluid fluxes for orifice type releases. These releases had length-to-diameter (L/D) ratios less than 0.88. Figure E-2 compares computed and experimental release fluxes for an L/D ratio of 120 at several levels of storage pressure. Figure E-3 compares similar releases for an L/D of 37.5. Figure E-4 shows predicted and experimental release fluxes at a given pressure for L/D ratios from 1 to 200.

Figures E-5 and E-6 compare computed and experimental gas discharge rates for the complete breach of two pipes. One pipe had an internal diameter of 6.2 inches (0.157 m); the other had a diameter of 12 inches (0.305 m). These pipes were initially pressurized to 1,000 psia with air and then explosively ruptured. The experimental values were reported in a research paper for Alberta Environment, authored by Wilson [1981].

Aerosols and Liquid Droplet Evaporation

Liquids stored at temperatures above their atmospheric pressure boiling point (superheated liquids) will give off vapor when released from storage. If the temperature of storage is sufficiently above the normal boiling point, the energy of the released vapor will break the liquid stream into small droplets. If these droplets are small enough, they will not settle, but remain in the vapor stream as aerosol droplets. The presence of aerosol droplets in the vapor stream changes its apparent density and provides an additional source of vapor. Droplets large enough to fall to the ground will lose mass due to evaporation during their fall.

The prediction of aerosol formation and amount of aerosol formed is based on the theoretical work performed for the Center for Chemical Process Safety (CCPS) by CREARE. CREARE's work has been extended and corrected by Quest. The extension to the model computes the non-aerosol drop evaporation. In Figure E-7, the four experimental data sets available for comparison (chlorine (Cl_2), methylamine (MMA), CFC-11, and cyclohexane) are compared to the values computed by the CANARY Aerosol Model.

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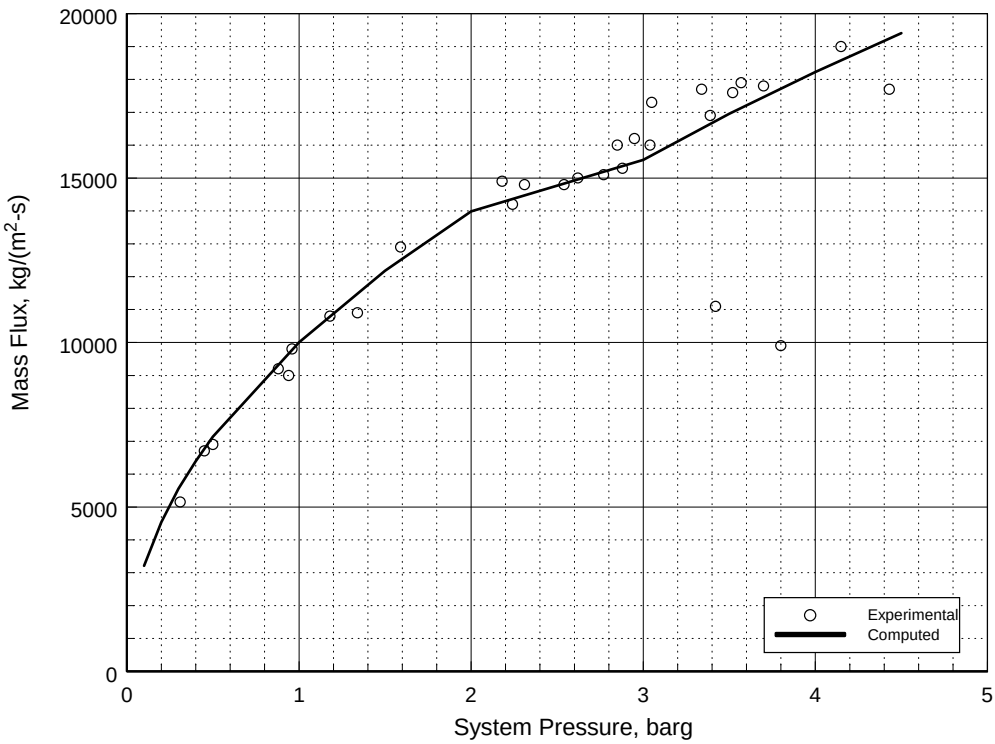

Figure E-1
Comparison of CFC-11 Orifice Releases as a Function of System Pressure

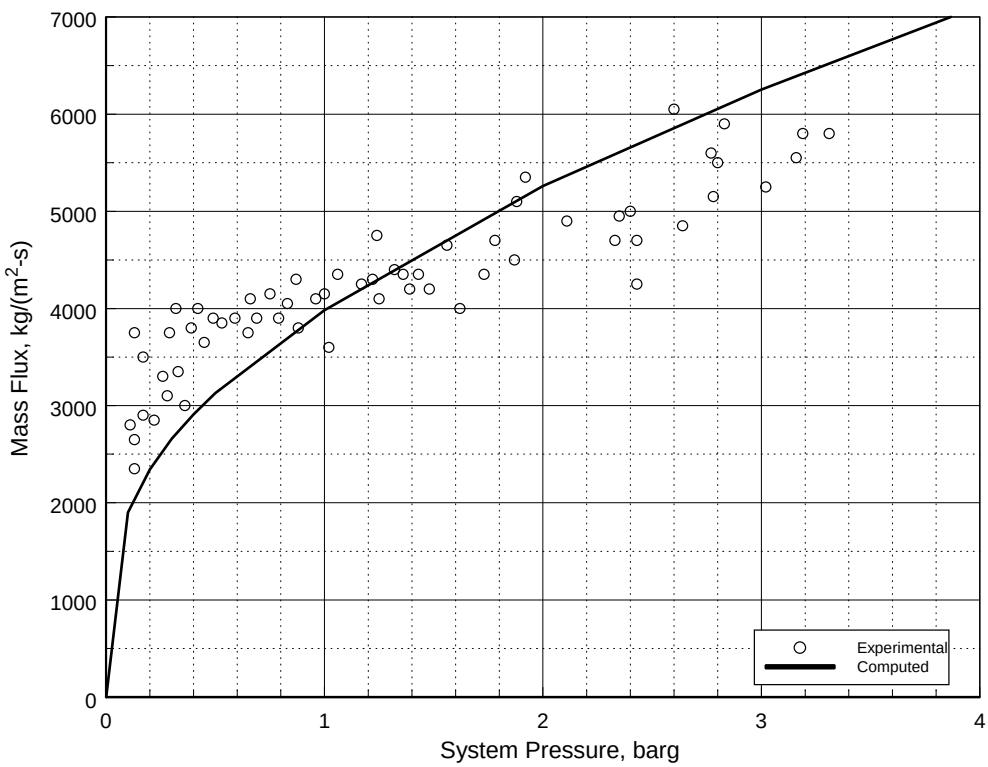

Figure E-2
CFC-11 Release Rate Comparison with L/D of 120

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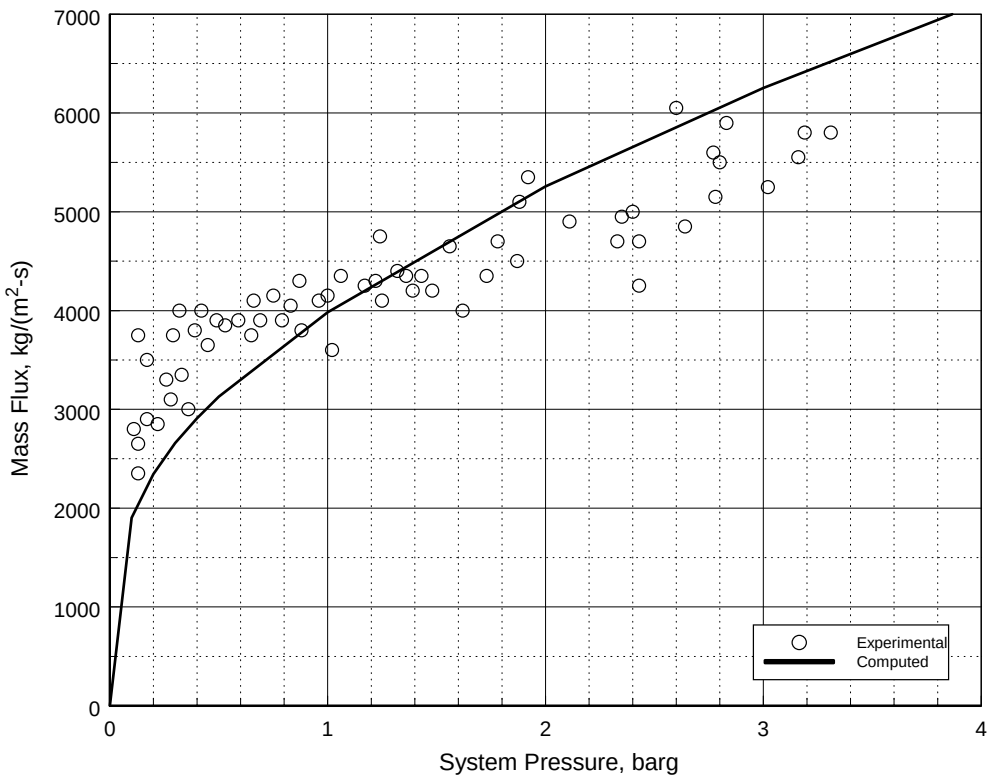

Figure E-3
CFC-11 Release Rate Comparison with L/D of 37.5

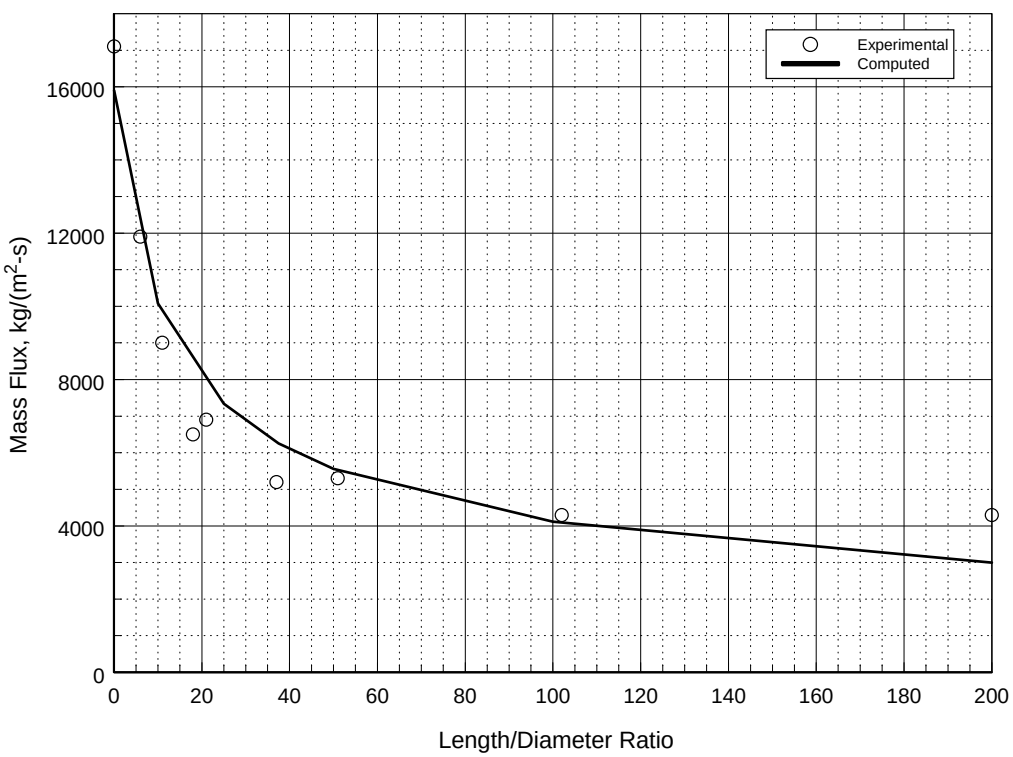

Figure E-4
CFC-11 Release Rate Comparison at Varying L/D Ratios

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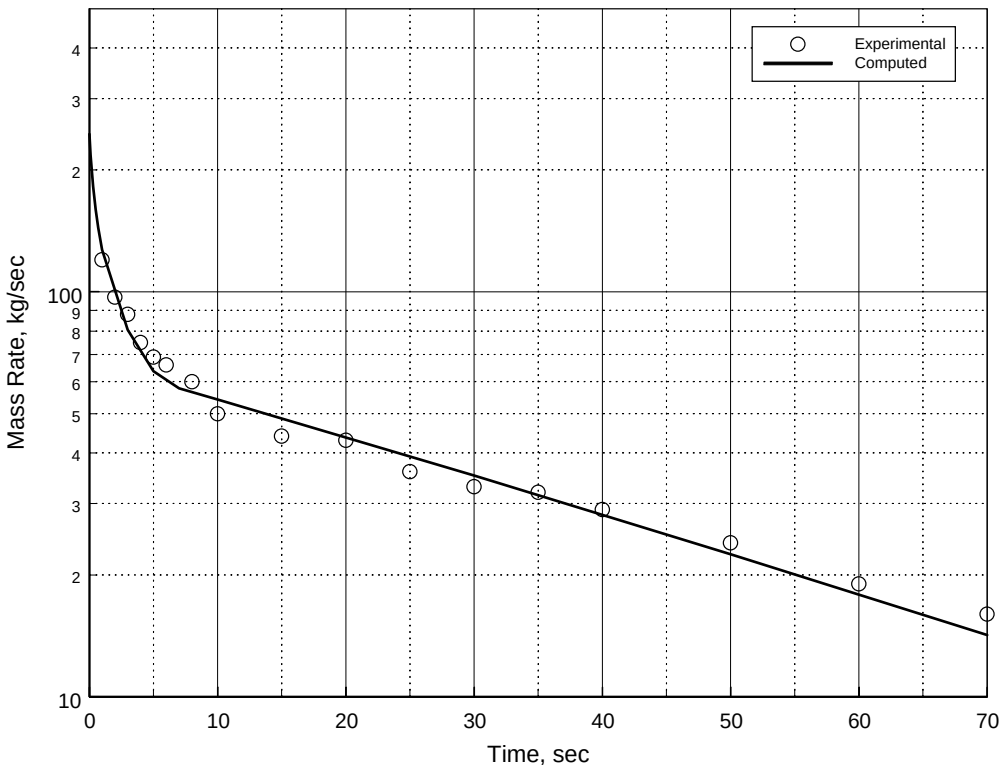

Figure E-5
Air Discharge Rates for 0.157 m Diameter Piping

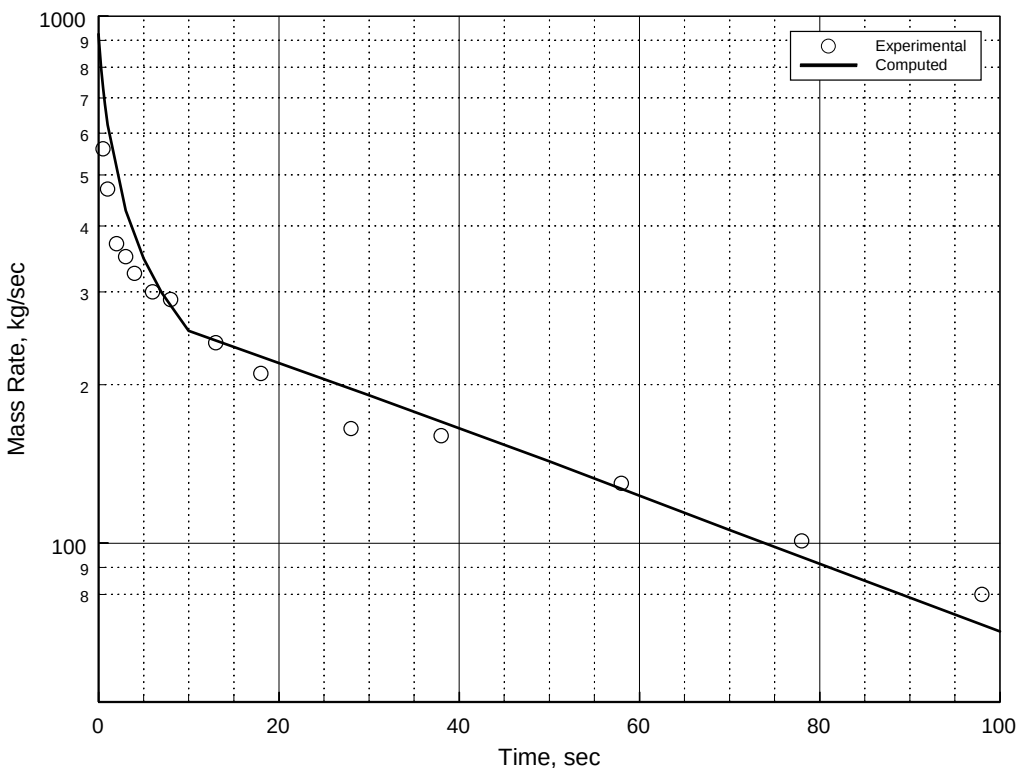

Figure E-6
Air Discharge Rates for 0.305 m Diameter Piping

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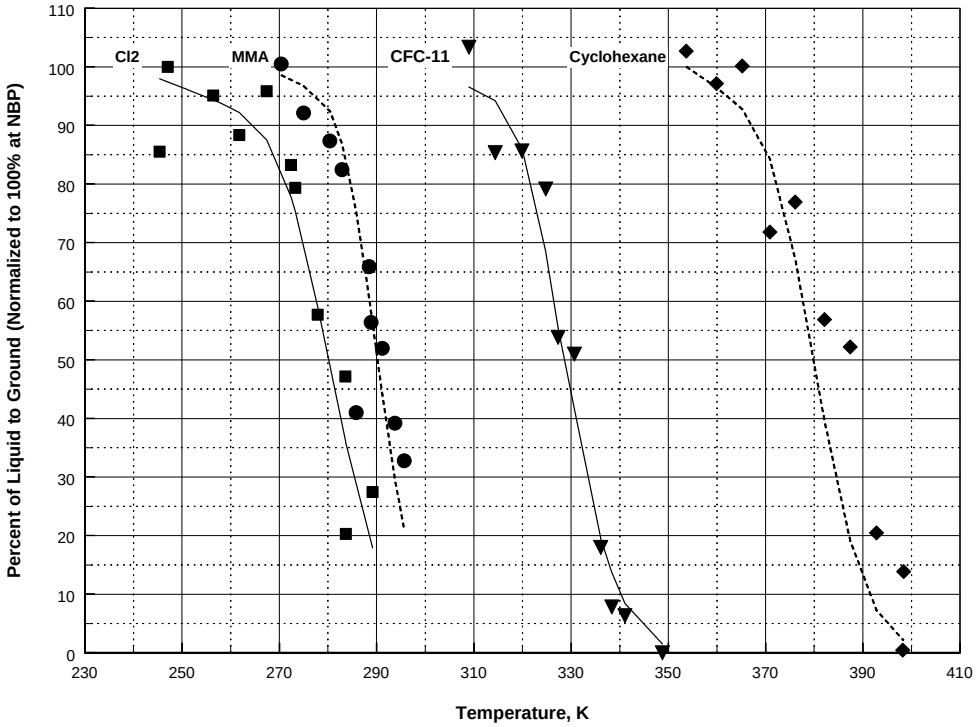

Figure E-7
Aerosol Formation as a Function of Storage Temperature

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Momentum Jet Dispersion Model

Purpose

The purpose of this model is to predict the dispersion of a jet release into ambient air. It is used to predict the downwind travel of a flammable or toxic gas or aerosol momentum jet release.

Required Data

(a) Composition and properties of the released material
(b) Temperature of released material
(c) Release rate of material
(d) Vertical release angle relative to wind direction
(e) Height of release
(f) Release area
(g) Ambient wind speed
(h) Ambient Pasquill-Gifford stability class
(i) Ambient temperature
(j) Relative humidity
(k) Surface roughness scale

Methodology

Step 1: An assumption is made that flow perpendicular to the main flow in the plume is negligible, that the velocity and concentration profiles in the jet are similar at all sections of the jet, that molecular transport in the jet is negligible, and that longitudinal turbulent transport is negligible when compared to longitudinal convective transport. The coordinate system is then defined in s and r, where s is the path length of the plume and r is the radial distance from the plume centerline. The angle between the plume axis and horizontal is referred to as θ. Relationships between the downwind coordinate, x, vertical coordinate, y, and plume axis are given simply by:

$$\frac{dx}{ds} = \cos(\theta) \tag{1}$$

and

$$\frac{dy}{ds} = \sin(\theta) \tag{2}$$

Step 2: Velocity, concentration, and density profiles are assumed to be cylindrically symmetric about the plume axis and are assumed to be Gaussian in shape. The three profiles are taken as:

$$u(s,r,\theta) = U_a \bullet \cos(\theta) + u^*(s) \bullet e^{\frac{-r^2}{b^2(s)}} \tag{3}$$

where: u = plume velocity, m/s
U_a = ambient wind speed, m/s

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u^* = plume velocity relative to the wind in the downwind direction at the plume axis, m/s
$b(s)$ = characteristic width of the plume at distance s from the release, m

$$\rho(s,r,\theta) = \rho_a + \rho^*(s) \bullet e^{\frac{-r^2}{\lambda^2 \bullet b^2(s)}} \tag{4}$$

where: ρ = plume density, kg/m^3
ρ_a = density of ambient air, kg/m^3
$\rho^*(s)$ = density difference between plume axis and ambient air, kg/m^3
λ^2 = turbulent Schmidt number, 1.35

$$c(s,r,\theta) = c^*(s) \bullet e^{\frac{-r^2}{\lambda^2 \bullet b^2(s)}} \tag{5}$$

where: c = pollutant concentration in the plume, kg/m^3
$c^*(s)$ = pollutant concentration at plume centerline, kg/m^3

Step 3: The equation for air entrainment into the plume and the conservation equations can then be solved. The equation for air entrainment is:

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \rho \bullet u \bullet 2 \bullet \pi \bullet dr\right) = 2 \bullet \pi \bullet b \bullet \rho_a \bullet \left\{\alpha_1 \bullet |u^*(s)| + \alpha_2 \bullet U_a \bullet |\sin(\theta)| \cos(\theta) + \alpha_3 \bullet u'\right\} \tag{6}$$

where: α_1 = entrainment coefficient for a free jet, 0.057
α_2 = entrainment coefficient for a line thermal, 0.5
α_3 = entrainment coefficient due to turbulence, 1.0
u' = turbulent entrainment velocity (root mean square of the wind velocity fluctuation is used for this number), m/s

Step 4: The equations of conservation of mass, momentum, and energy are given as:

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} c \bullet u \bullet 2 \bullet \pi \bullet dr\right) = 0 \tag{7}$$

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \left(\rho \bullet u^2 \bullet \cos(\theta) \bullet 2 \bullet \pi \bullet dr\right)\right) = 2 \bullet \pi \bullet b \bullet \rho_a \bullet \left\{\alpha_1 \bullet \left|u^*(s)\right| + \alpha_2 \bullet U_a \bullet \left|\sin(\theta)\right| \bullet \cos(\theta) + \alpha_3 \bullet u'\right\} + C_d \bullet \pi \bullet b \bullet \rho_a \bullet U_a^2 \left|\sin(\theta)\right| \tag{8}$$

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \rho \bullet u^2 \bullet \cos(\theta) \bullet 2 \bullet \pi \bullet dr\right) = \int_0^{b\sqrt{2}} g \bullet (\rho_a - \rho)\, \pi \bullet r \bullet dr \pm C_d \bullet \pi \bullet b \bullet \rho_a \bullet U_a^2 \bullet \sin(\theta) \bullet \cos(\theta) \tag{9}$$

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \rho \bullet u \left(\frac{1}{\rho} - \frac{1}{\rho_{a0}}\right) \bullet 2 \bullet \pi \bullet r \bullet dr\right) \tag{10}$$

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$$= \rho_a \bullet 2 \bullet \pi \bullet b \left(\frac{1}{\rho_a} - \frac{1}{\rho_{a0}} \right) \bullet \left\{ \alpha_1 \bullet |u^*(s)| + \alpha_2 \bullet U_a \sin(\theta) | \bullet \cos(\theta) + \alpha_3 \bullet \acute{u} \right\}$$

The subscript 0 refers to conditions at the point of release. These equations are integrated along the path of the plume to yield the concentration profiles as a function of elevation and distance downwind of the release.

Step 5: After the steady-state equations are solved, an along-wind dispersion correction is applied to account for short-duration releases. This is accomplished using the method outlined by Palazzi, et al. [1982].

Step 6: If the plume reaches the ground, it is coupled to the Heavy Gas Dispersion Model (described in Section G) and the dispersion calculations continue.

Validation

The Momentum Jet Dispersion Model used in CANARY was validated by comparing results obtained from the model with experimental data from field tests. Data used for this comparison and the conditions used in the model were taken from an American Petroleum Institute (API) study [Hanna, Strimaitis, and Chang, 1991]. For this model, comparisons were made with the Desert Tortoise, Goldfish, and Prairie Grass series of dispersion tests. Results of these comparisons are shown in Figure F-1.

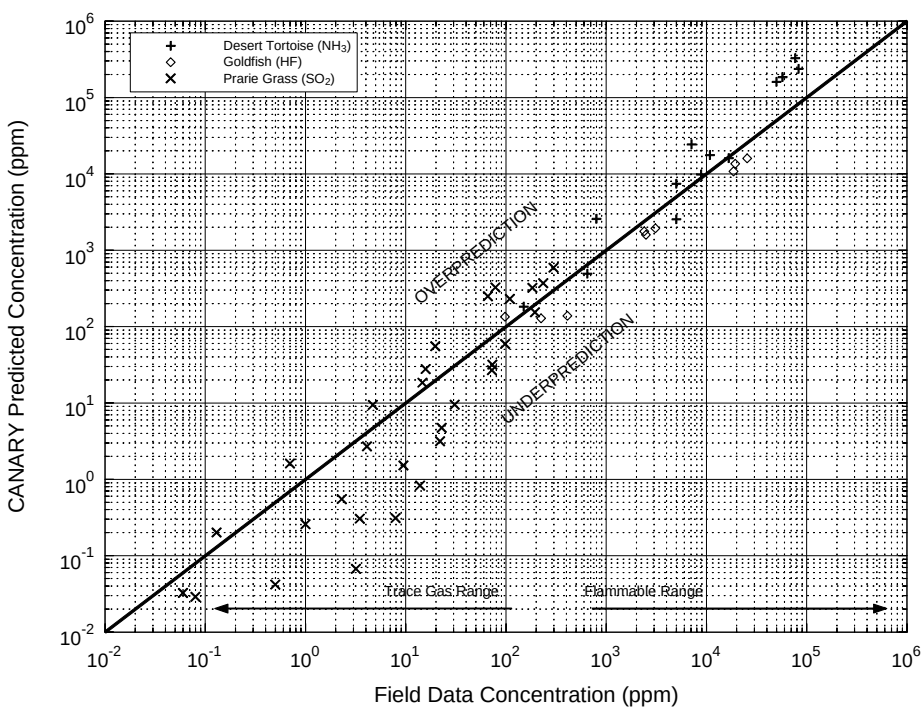

Figure F-1

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Estimating Flame Speeds for Use with the BST Blast Curves

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Estimating Flame Speeds for Use with the BST Blast Curves

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ABSTRACT

The Baker-Strehlow-Tang (BST) vapor cloud explosion model is one of the most common methods used to estimate overpressures for the purpose of locating buildings in relation to process units. This model suffers from a problem common to all simplified explosion models: the user is required to pick the "strength" of the explosion using one or more simple parameters. In the BST model, the fuel reactivity, flame expansion, and obstacle density parameters are used to select a flame speed from a limited matrix of possible values. This paper presents the Quest Model for Estimation of Flame Speeds (QMEFS), a systematic approach to estimating flame speed that does not rely on the BST categories. It provides for a continuous range of flame speeds that can then be used with the existing BST blast curves to calculate the characteristics of the vapor cloud explosion. The QMEFS approach provides the user with a method for describing a VCE that is more detailed than the BST model, and establishes a more refined system for predicting the consequences of vapor cloud explosions.

1. INTRODUCTION

Any release of a flammable fluid in a petrochemical facility has the potential to generate a flammable vapor cloud that, if ignited, could produce a vapor cloud explosion (VCE). If the VCE generates damaging levels of overpressure, the possibility of human injury/death, asset damage, or event escalation becomes a concern. The concern for human injury or death is most often addressed in the form of a building siting study. Because people are somewhat less likely to be injured or killed when outside, as compared to when inside a building, the siting study focuses on the potential impacts to buildings within and around petrochemical facilities. It then becomes the task of process safety professionals to estimate the potential for VCE events, and their resulting overpressure impacts on buildings. Prediction of the overpressures resulting from a VCE is typically done using one of two categories of models: computational fluid dynamics (CFD) models and simplified models.

CFD models calculate the overpressure field by solving the Navier-Stokes equations numerically and incorporating different sub-models to account for turbulence and combustion reactions. Results are often strongly dependent on the location and strength of the ignition point, the location and composition of the flammable cloud throughout its volume, and the location and configuration of any obstacles or obstructions within the cloud. The time required to calculate the overpressures resulting from a single ignition point/cloud geometry/location geometry can be significant. Given the number of combinations of ignition points and cloud geometries (e.g., changes in wind direction or wind speed) that can influence a given flammable release; it is generally prohibitive to use CFD for risk assessment or building siting purposes.

Simplified models such as the Baker-Strehlow-Tang (BST) model or the TNO Multi-energy model use information taken from CFD studies to generate curves defining the relationship between explosion

overpressure and distance from the explosion center. These curves can then be used in a more general manner to estimate the overpressure impacts generated by an exploding vapor cloud. However, both approaches, require the user to estimate the strength of the explosion as a function of the reactivity of the flammable material and the degree of confinement or congestion present in the cloud. This information is then used to determine which strength curve (in the case of the TNO model) or flame speed (in the case of the BST model) is used to calculate the overpressure of the explosion as a function of distance from the center of the explosion.

The TNO Multi-energy model provides little guidance for selecting the explosion strength curve. Curves for strengths in the range of 1 to 10 are provided, and it is left to the user to determine how the reactivity of the flammable gas and the degree of confinement or congestion relate to one of these curves.

The BST model is based on a simple set of guidelines that result in a selection of a flame speed, which corresponds to an overpressure vs. distance curve. Three parameters are used to determine the flame speed to be used: reactivity of the flammable gas, the degree of confinement of the flammable cloud, and the degree of obstruction due to obstacles within the flammable cloud. Reactivity is divided into three categories: low, medium, and high. According to the current BST model, materials having a laminar flame speed greater than 0.75 m/s are considered high reactivity [2] while those having a laminar flame speed below 0.4 m/s are considered low reactivity[2] (the threshold for high reactivity was originally set at 0.8 m/s [1]). All other materials are considered to be medium reactivity. The effect of the confinement of the flammable cloud is taken into account by determining the number of dimensions in which the burning gas may expand. 3-D expansion allows the burning cloud to expand freely in all directions and results in the slowest flame acceleration and lowest overpressures. 2-D expansion, such as a flame between two flat plates, generates higher overpressures because the combustion gases have fewer directions in which to expand resulting is a higher flame acceleration. Finally, 1-D expansion is used for planar flames propagating in pipes. The effect of obstacles in the flammable cloud is characterized by the obstacle density, classified as low, medium, or high. In the original Baker-Strehlow model, low obstacle density was defined as having an area blockage ratio (ABR) of less than 10%, while high obstacle density was defined as an ABR of 40% or greater, and everything in between is considered medium [1].

One problem with the BST scheme is that there are often large jumps in flame speed between categories of confinement, reactivity, or obstruction. This problem was first addressed by Baker in a 1998 paper [2] where a new confinement category, 2½-D, was added for those situations that were more confined than the 3-D case, but less so than the 2-D case. The flame speeds used for the 2½-D confinement were simply the arithmetic average of the flame speeds for the 2-D and 3-D cases for a given reactivity and congestion class. Even with this extension, large discontinuities remained among the categories for flame speed according to the prescribed methodology. These discontinuities drive the need for a new method to determine flame speed based upon quantifiable properties of the flammable gas and its surroundings that varies smoothly across the range of conditions that are found in actual process plants.

The model presented in this paper provides a method for estimating the maximum flame speed that may be expected following ignition of a flammable cloud. That flame speed may then be used with the BST blast curves to estimate the overpressure impacts in the area surrounding a vapor cloud explosion.

2. PARAMETERS AFFECTING FLAME SPEED

2.1 Reactivity

Fuel reactivity is a measure of the propensity of the flame front in a given flammable mixture to accelerate and create overpressures or potentially undergo a deflagration-to-detonation transition (DDT).

In the BST model, reactivity is classified as high, medium, or low based on the laminar flame speed of the fuel-air mixture. These categories have been given boundaries, effectively placing certain materials in each category. For example, the laminar flame speed of ethylene, depending on the cited reference, ranges between 0.64 and 0.83 m/s. In the original Baker-Strehlow model, the division between medium and high reactivity categories was 0.8 m/s [1]. In 1998, this division was re-defined as 0.75 m/s. This clearly makes ethylene a "borderline" fuel – one that may either be defined as medium or high reactivity. In the latest published BST model [9], ethylene is explicitly categorized as a high reactivity material, as their experimental work defined ethylene as the high reactivity material. This then begs the question: what about ethylene oxide (laminar flame speed 1.0 m/s) or acetylene (laminar flame speed 1.6 m/s)? These two materials are clearly more reactive than ethylene, but are still categorized as high reactivity. The BST model effectively says that an ethylene explosion will be as severe as an ethylene oxide explosion, when all other parameters are held constant.

2.2 Congestion

Congestion in the original Baker-Strehlow VCE [1] model was classified as high, medium, or low based on the area blockage ratio (ABR) of obstructions in the path of the expanding flame front. Later guidelines produced for the BST model in light of more recent data seem to suggest that the volume blockage ratio (VBR) is a better parameter for classifying an obstructed area [9]. In practice, both blockage ratios will effect how fast a flame accelerates, but, for a uniform obstacle field, the two are related simply by the pitch-to-diameter ratio of the obstacles. If the obstacles included in the ABR are not repeated quasi-uniformly throughout the obstacle field but are only present in distinct planes, their effect would be more accurately portrayed by something similar to a confinement parameter.

2.3 Confinement

The effect of confinement is included in the BST model by identifying the number of dimensions that are available to the products of combustion for expansion. Expansion into free space is considered 3-D expansion, expansion between two parallel planes is considered 2-D expansion, and expansion in a pipe is considered 1-D expansion. The 1-D case was removed in the more recent publications discussing the BST model [9]. To handle the case of a frangible or partially-confining plane, such as a very closely spaced pipe rack, the BST model added a 2.5-D classification which simply averaged the 2-D and 3-D flame speed results.

2.4 Other Factors

Several researchers [3,6,9] have acknowledged that the overall dimensions of the flammable vapor cloud before ignition directly affect the final flame speed and consequent overpressures of the vapor cloud explosion. Since a flame will accelerate until it undergoes DDT or reaches a maximum sustainable value, the maximum dimension of a flammable cloud is expected to be an important variable in the creation of overpressure. In addition, research [3,4,5,6] suggests that the scale of obstacles within the congested area also affects the maximum flame speed that may be achieved. Both of these factors should be included in any correlation for the prediction of flame speeds in vapor clouds.

3. NEW MODEL FOR ESTIMATING FLAME SPEED

Portions of existing modeling methodologies and experimental data sets have been used in order to create a new model that provides the capability for more detailed descriptions of explosion scenarios. This new model bases the prediction of overpressure on the following parameters:

- Laminar flame speed is used as the characteristic property for fuel reactivity.
- Volume blockage ratio and average obstacle diameter define the level of congestion.
- Confinement is characterized as the number of confining planes, or walls, that are available to confine the expanding gases.
- Length, width, and height of the explosion source region are used to define the volume of gas and the maximum flame acceleration path, or run-up distance.

The new method for defining release-specific flame speed combines information from the European MERGE and EMERGE tests [11] and the BST model [10] with the new values for flame speed given for use in the BST model by Pierorazio, et al. [9].

3.1 Fundamental Correlations

The original Baker-Strehlow curves were presented in terms of M_w, the velocity of heat addition in the numerical calculations relative to a Lagrangian (moving) coordinate system. However, the actual flame speed measured in experiments, M_f, is based on an Eulerian (fixed) coordinate system. When presenting the new BST curves, Tang and Baker [10] presented the curves in terms of M_f, the measured flame velocity. To convert from M_w to M_f velocities, they determined the overpressure for a range of values of M_w and then converted them to M_f using the following equation derived from acoustic theory:

$$\frac{p_{\max} - p_0}{p_0} = 2.4 \cdot \frac{M_f^2}{1 + M_f} \qquad (1)$$

where:

p_{max} = the maximum overpressure attained, bara
p_0 = the ambient pressure, bara
M_f = the flame speed relative to a fixed observer, expressed as a Mach number

Based on extensive experimental research programs performed during the MERGE and EMERGE projects [3,4,5,6], TNO, in the GAMES project, developed the following correlation for explosion overpressure in 3-D flame expansion conditions [7]:

$$\Delta P_0 = 0.84 \cdot \left(\frac{VBR \cdot L_f}{D} \right)^{2.75} \cdot S_l^{2.7} \cdot D^{0.7} \qquad (2)$$

where:

ΔP_0 = the overpressure (equivalent to $p_{\max} - p_0$ in equation 7, above), bar
VBR = the volume blockage ratio
L_f = the maximum distance a flame may propagate in the obstructed region (i.e., the run-up distance), m
D = the average obstacle diameter, m
S_l = the laminar flame speed of the flammable gas, m/s

Combining equation 1 with equation 2, yields:

$$2.4 \cdot \frac{M_f^2}{1 + M_f} \cdot p_0 = 0.84 \cdot \left(\frac{VBR \cdot L_f}{D} \right)^{2.75} \cdot S_l^{2.7} \cdot D^{0.7} \qquad (3)$$

which gives a the following quadratic equation in M_f:

$$2.4 \cdot p_o \cdot M_f^2 - RHS_{3D} \cdot M_f - RHS_{3D} = 0 \quad (4)$$

where RHS_{3D} is the right hand side of equation 3:

$$RHS_{3D} = 0.84 \cdot \left(\frac{VBR \cdot L_f}{D} \right)^{2.75} \cdot S_l^{2.7} \cdot D^{0.7} \quad (5)$$

To simplify, p_0 was set equal to 1 bar, giving the solutions to this equation as:

$$M_f = \frac{RHS_{3D} \pm \sqrt{RHS_{3D}^2 + 9.6 \cdot RHS_{3D}}}{4.8} \quad (6)$$

Since all terms in RHS_{3D} are positive, and M_f must be positive, the only physically meaningful solution remaining is:

$$M_f = \frac{RHS_{3D} + \sqrt{RHS_{3D}^2 + 9.6 \cdot RHS_{3D}}}{4.8} \quad (7)$$

The GAMES project also produced a correlation for overpressure achieved by 2-D flame expansion [7], which takes the same form as equation 2. A solution for flame speed can be derived in the same manner as presented for the 3-D correlation using

$$RHS_{2D} = 3.38 \cdot \left(\frac{VBR \cdot L_f}{D} \right)^{2.25} \cdot S_l^{2.7} \cdot D^{0.7} \quad (8)$$

in place of RHS_{3D} in equations 4, 6, and 7.

A final correction is applied to the calculated flame speed for the number of planes that confine the expanding products of combustion. Assuming the entire mixture is burned, there is a relationship between the initial and final dimensions of the unburned gases and products of combustion and the available directions in which the cloud may expand. Defining α as the ratio of the volume of the products of combustion divided by the initial flammable gas volume (i.e. the expansion ratio), for a spherical cloud (3-D expansion):

$$\alpha = \frac{V_b}{V_u} = \frac{4/3 \cdot \pi \cdot r_b^3}{4/3 \cdot \pi \cdot r_u^3} \quad (9)$$

where:

V_u = volume of unburned gas
V_b = volume of combustion products
r_u = radius, unburned gas
r_b = radius, combustion products

which leads to:

$$r_b = \sqrt[3]{\alpha} \cdot r_u \qquad (10)$$

Similarly, for 2-D expansion:

$$\alpha = \frac{\pi \cdot r_b^2 \cdot h}{\pi \cdot r_u^2 \cdot h} \qquad (11)$$

where:

h = the height of the cylinder

or:

$$r_b = \sqrt{\alpha} \cdot r_u \qquad (12)$$

And finally, for 1-D expansion:

$$\alpha = \frac{\pi \cdot R^2 \cdot r_b}{\pi \cdot R^2 \cdot r_u} \qquad (13)$$

where:

R = the radius of the pipe
r_u = length, unburned gas in the pipe
r_b = length, combustion products in the pipe

or:

$$r_b = \alpha \cdot r_u \qquad (14)$$

To correct the flame speed to account for confinement, a curve fit of the ratio of burned cloud to unburned cloud radii versus the number of confining planes was made. The values resulting from Equations 10, 12, and 14 were used to generate the curve fit with α = 7, a typical expansion ratio for common hydrocarbon fuels in air. This is also the value assumed in the derivation of Equation 1, as presented in Tang and Baker [10]. The equation resulting from this curve fit is:

$$NPF = \frac{1}{0.5035 - 0.0757 \cdot nPlanes} - 1.338 \qquad (15)$$

where:

NPF = flame speed correction factor
nPlanes = number of confining planes

For true 3-D spherical expansion, *nPlanes* = 0. For a typical explosion at grade level, *nPlanes* = 1. For 2-D expansion, such as a flame propagating between a floor and a ceiling, *nPlanes* = 2. For 1-D expansion, such as a flame front moving in one direction in a pipe, *nPlanes* = 5. Planes that are not completely solid or rigid may be accounted for using a fraction of a plane.

The flame speed correction factor, *NPF*, does not fully account for increases in flame speed as the number of confining planes increases. This is seen directly when comparing the flame speed predicted by the 2-D

GAMES correlation (applying equation 8 to equation 7) to the flame speed predicted by the 3-D GAMES correlation (applying equation 5 to equation 7) and adjusting by *NPF* when *nPlanes* is equal to 2. In order to supplement *NPF*, flame speeds are also corrected so that they match the 2-D GAMES correlation. This is accomplished by applying the following factor to the flame speed when *nPlanes* is equal to 2:

$$\beta = \frac{M_{f,2D}}{M_{f,3D} \cdot NPF(nPlanes = 2)} \tag{16}$$

This can be implemented in a general form, such that it can be applied to all calculations of flame speed, using the following relationship:

$$M_f = M_{f,3D} \cdot NPF \cdot \left[1 + (\beta - 1)(nPlanes - 1)\right] \tag{17}$$

3.2 Flame Speed Limits

One problem with equation 7 is that it does not limit the predicted flame speed for large values of L_f or S_l, allowing it to increase nearly as fast as the cube of their values. This is a direct result of the correlation fitting the data within the scope of the MERGE and EMERGE tests. In reality, for a given obstacle configuration, geometry, and flammable gas mixture, there is a limit to the flame speed that can be achieved. This flame speed may be either subsonic or the cloud may undergo a deflagration-to-detonation transition (DDT) in which the flame front becomes a detonation propagating at roughly the Chapman-Jouguet (C-J) detonation velocity for the flammable mixture. For most common flammable hydrocarbons in air, this speed is roughly 1800 m/s or M_f= 5.2.

The flame speeds suggested by the latest BST model [9] are applied as the upper limit flame speeds to be used in this model, as they have been "scaled up" to account for industrial scale flammable clouds [9] and account for DDTs. For purposes of this model, any flame that accelerates to a calculated velocity greater than M_f = 3.0 is considered to have undergone DDT [8,12] and the flame speed is set to the C-J velocity, M_f = 5.2. The parameters in the new model described in this paper corresponding to the existing BST conditions are listed in Table 1.

Table 1
BST Flame Speed Parameters

BST Parameter	Category	New Model Parameter	Corresponding Parameter Value
Reactivity	Low (e.g., Methane)	S_l	0.37 m/s
	Medium (e.g., Propane)		0.43 m/s
	High (e.g., Ethylene)		0.76 m/s
Obstacle Density	Low	*VBR*	0.015
	Medium		0.043
	High		0.057
Expansion	3-D	*nPlanes*	1
	2-D		2
	1-D		5

The characteristic obstacle diameter for the BST tests was 2 inches (0.0508 meters) and the length available for flame acceleration was 15 meters [9]. To determine the maximum allowable flame speed for any given combination of *VBR*, S_l, *D*, L_f and *nPlanes*, the given values are linearly interpolated from the values presented in Pierorazio, et al. [9]. This approach is consistent with the approach used in Baker, et al. [2] to determine flame speed for expansion geometries between 3-D and 2-D, i.e. 2½-D expansion.

The result of these correlations is a model that estimates the flame speed based on *VBR*, *D*, S_l, L_f and the number of confining planes. The resulting flame speed is compared to the published BST model, which provides a matrix of flame speeds as a function of reactivity, obstacle density, and flame expansion. The BST matrix values are used as maximum flame speed values for the set of parameters given in Table 1. Values between or outside the BST matrix elements are calculated by linear interpolation (as was done for Baker's 2½-D flame expansion category). This methodology provides an extended, systematic approach for estimating flame speeds resulting from the combustion of a flammable cloud in an obstructed and/or confined region. Predicted flame speeds are used with the existing BST blast curves to produce estimates of overpressure at a distance from the explosion source.

4. RESULTS

As discussed in the paper outlining the most recent version of the BST model [9], the distance that is available for the flame to accelerate, i.e. the run-up distance, can have a significant effect on the flame speed attained in a flammable gas cloud. The flame speeds presented in the original Baker-Strehlow (BS) model [1] were generated in a test rig whose largest dimension was less than 6 feet (1.8 meters) [9]. The flame speeds used in the newest BST model are based on tests where the largest dimension was 48 feet (14.6 meters) with the published flame speed results "scaled up" to account for the maximum size of a typical industrial plant. One test of the QMEFS model is to determine the flame speed versus run-up distance for the test configurations used in the newest BST model when specific parameters are varied.

Figure 1 shows the results for the 3-D, medium reactivity case. The curves plotted in Figure 1 show four VBR values – the medium value of 4.3% used in the latest BST experiments, the low congestion value of 1.5% used in the latest BST experiments, and two intermediate values to show how the model behaves as the VBR is adjusted.

Figure 2 shows the new flame speed model for the 3-D, high congestion case. In the new BST model [9], the cloud undergoes a DDT if the fuel reactivity is high. The older BS model [2] failed to predict this behavior. Four curves for varying reactivity (laminar flame speed) are shown. The lowest laminar flame speed, 0.43 m/s for propane, corresponds to the medium reactivity category in the newest BST experiments. The highest laminar flame speed, 1.0 m/s for ethylene oxide, corresponds to the high reactivity category in the newest BST experiments. Curves for ethylene (S_l = 0.75 m/s, high reactivity in BST) and cyclopropane (S_l = 0.52 m/s, medium reactivity in BST) are also shown illustrate how the new model for flame speeds allows for a continuous spectrum of predicted values between the extremes of the BST categories.

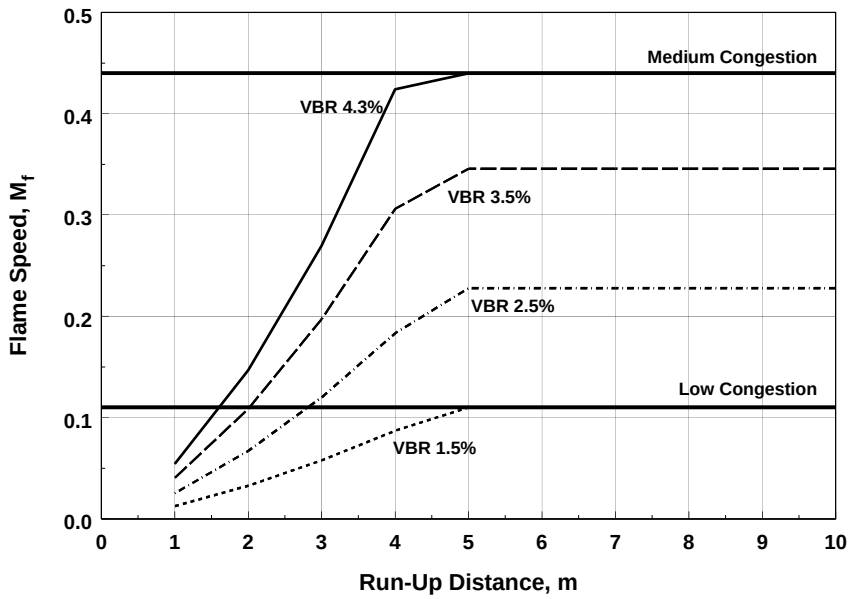

Figure 1
Flame Speed vs. Run-Up Distance
3-D, Propane, D = 2"

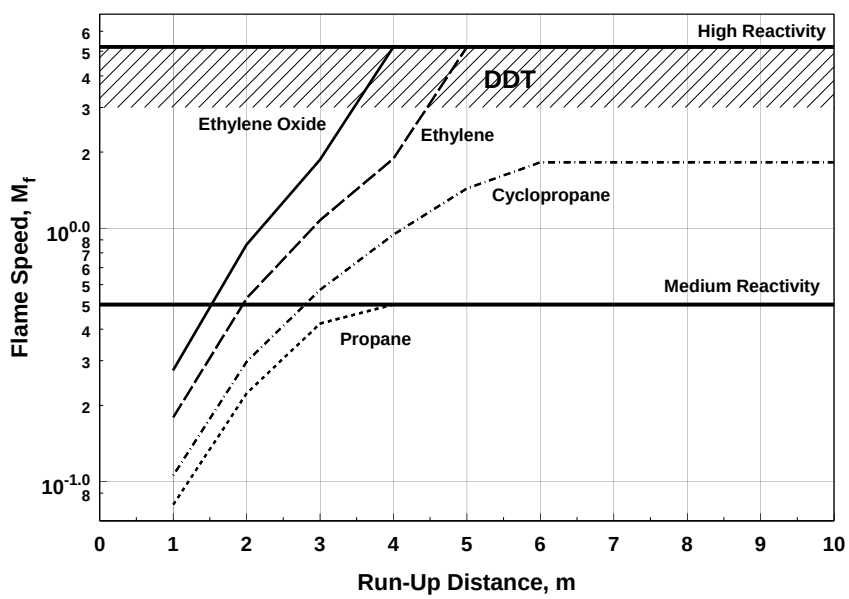

Figure 2
Flame Speed vs. Run-Up Distance
3-D, VBR=4.3%, D = 2”

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5. CONCLUSIONS

The model described in this paper provides a method to better describe the characteristics of a vapor cloud explosion over a wide range of conditions. It combines elements of the work conducted by Baker and the European MERGE/EMERGE projects, thus incorporating data from the two largest, modern vapor cloud explosion test projects. With the ability to model the reactivity of a flammable gas cloud based on laminar flame speed instead of a low, medium, or high classification, the model is able to more accurately describe a wide range of flammable gases and mixtures. Also, due to the ability to describe the obstacle congestion with a volume blockage ratio parameter and an average obstacle diameter, the analyst can provide a better description of the region that a flammable cloud occupies. Using the predicted flame speed and the curves for overpressure and impulse presented in the BST model, process safety experts may calculate the impacts the explosion of a flammable cloud will have on buildings in proximity to petrochemical facilities.

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Economic and Fiscal Impact of the Finger Lakes LPG Storage Project

FINAL REPORT

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Prepared for:

Finger Lakes LPG Storage, LLC

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About Camoin Associates

Camoin Associates has provided economic development consulting services to municipalities, economic development agencies, and private enterprises since 1999. We specialize in real estate market analysis to evaluate the feasibility and impacts of proposed projects. Through the services offered, Camoin Associates has had the opportunity to serve EDOs and local and state governments from Maine to Texas; corporations and organizations that include Lowe's Home Improvement, FedEx, Volvo (Nova Bus) and the New York Islanders; as well as private developers proposing projects in excess of $600 million. Our reputation for detailed, place-specific, and accurate analysis has led to projects in twenty states and garnered attention from national media outlets including *Marketplace (NPR)*, *Forbes* magazine, and *The Wall Street Journal*. Additionally, our marketing strategies have helped our clients gain both national and local media coverage for their projects in order to build public support and leverage additional funding. The firm currently has offices in Saratoga Springs, NY, Portland, ME, and Brattleboro, VT. To learn more about our experience and projects in all of our service lines, please visit our website at www.camoinassociates.com. You can also find us on Twitter @camoinassociate and on Facebook.

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Executive Summary

Finger Lakes LPG Storage, LLC hired Camoin Associates to conduct an economic and fiscal impact study of its proposed liquid petroleum gas (LPG) storage Project (the "Project") in the Town of Reading, NY. As such, this impact analysis is designed to quantify how the proposed Project will impact the economy of Schuyler County and the municipal revenues and expenses of local governments (county, town, school district and fire district). The analysis considers the potential sources of impact from the Project and analyzes each one to determine if that impact is likely to occur and, if so, how that impact can be quantified. The economic impact of the Project is expressed as a change in sales (economic output), jobs, and earnings. The fiscal impact of the Project is expressed as the change in tax revenue and municipal spending associated with the Project.

The results of the study indicate that the net economic impact of the Project is expected to be positive. Overall, the Project will have a *one-time* economic impact to Schuyler County of 58 jobs, $2.3 million in earnings, and $5.6 million in economic output. Additionally it will generate an *annual* economic impact of 17 jobs, $684,000 in earnings, and $507,000 in indirect economic output in the County. The net fiscal impact of the Project (i.e. municipal revenues less expenditures related to the Project) will be $613,000 annually.

The following highlights the major findings of this study, with more information and detail provided in the full report. Conclusions are provided for each of the potential sources of economic impact that were analyzed in the report.

Visual Impact

According to an expert report, it appears that the visual impacts of the Project will be minimal because: (1) topography and vegetation would conceal most of the Site and structures, (2) for portions of the Site that would be visible, effective mitigation techniques will be employed, and (3) the overall visual character of the area would not be altered significantly. No economic impact anticipated.

Noise from Operations

The sound analysis completed by an independent third-party consulting firm found that sound levels would be effectively mitigated and would therefore be "non-objectionable." No economic impact anticipated.

Truck and Train Traffic

There will be no new truck traffic generated as a result of the Project and any additional rail traffic will be negligible relative to existing conditions. No economic impact anticipated.

Potential for Catastrophic Events

The Site has been vetted and approved by numerous experts and regulatory officials for its intended use. Comprehensive safety features have been integrated into the Site's design. Based on an expert Quantitative Risk Analyses, there does not appear to be any meaningful risk of a catastrophic event at the Site to disrupt local economic activity. Furthermore, catastrophic events related to the transport of product to and from the Site appear to have a near-zero probability of occurrence. No economic impact anticipated.

Olfactory Impacts

The only potential source of odor is the minute amount of mercaptan used to odorize propane as it is loaded onto trucks for local delivery as required for safety purposes. However, the mercaptan is confined to a sealed system and does not appear to have any significant impact off the Site itself. No economic impact anticipated.

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Health Impacts

Neither air pollution nor on-site chemicals will result from the Project and therefore there will be no health impacts. No economic impact anticipated.

Tourism Impacts

Tourism is an important aspect of the local economy and has not appeared to be adversely impacted by the existing LPG and natural gas storage activities as well as other industrial activities (e.g., two salt manufacturing facilities) that have occurred or are occurring in and around the Project Site. Furthermore, as outlined above, there appear to be no visual, noise, traffic, smell, health or other adverse conditions related to the Project that might potentially impact tourism. We can find no basis to expect a meaningful impact on tourism. No economic impact anticipated.

Property Value Impacts

The Project Site has been in continuous industrial use for decades, and is being and has been used for bulk storage of hydrocarbons for quite some time (previously for propane storage and currently for natural gas storage). As such, the proposed Project's use of the Site is consistent with historical patterns of use on the Project Site and in the Town. Furthermore, there appears to be no literature in support of a negative impact on property values from LPG storage. As with the tourism section, we can find no reasonable basis to expect surrounding property values to diminish due to the nature of the Project (visual, noise, traffic, etc.). Furthermore, the anticipated positive economic benefits of the Project are evidenced by the broad local support for the project including vineyards, farm organizations, and businesses representing a significant portion of the employment base in the region. No economic impact anticipated.

Project Construction

Construction of the Project will inject money into the County economy by providing employment opportunities. The table below shows the one-time impact of construction in terms of direct and indirect jobs, earnings and sales.

One-Time Construction Impacts: Schuyler County			
	Direct	Indirect	Total
Jobs	50	8	58
Earnings	$2,046,993	$225,169	$2,272,162
Sales	$17,400,228	$609,212	$18,009,440

Source: Direct impacts provided by Finger Lakes LPG Storage, LLC; Indirect impacts modeled by Camoin Associates using EMSI

Construction of the Project will generate a one-time economic impact of 58 jobs, $2.3 million in earnings, and $18 million in sales (economic output).

Operational Spending/Employment

The annual economic impact of the Project will come from (a) workers who spend a portion of their wages in the local economy, and (b) certain business-to-business purchases, both of which support the local employment base.

Annual Impact from Operations: Schuyler County			
	Direct	Indirect	Total
Jobs	11	6	17
Earnings	$491,340	$193,052	$684,392

Source: Direct impacts provided by Finger Lakes LPG Storage, LLC; Indirect impacts modeled by Camoin Associates using EMSI

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Project operations will generate an annual economic impact of 17 jobs including 6 off-site (indirect) jobs generated in Schuyler County. The Project will generate approximately $684,000 in annual earnings in the County. Approximately $193,000 of those earnings are the indirect impact of the Project as wages paid to on-site (direct) workers are spent and circulated through the local economy. The indirect impact of the Project to Schuyler County also includes an indirect sales (economic output) impact of $507,000.

Fiscal Impacts

Property tax revenues will total approximately $617,000 annually while new municipal costs generated as a result of the Project are estimated to be approximately $3,760 annually. The table below breaks down the allocation of costs and revenues.

Summary: Net Fiscal Impact	
Revenues	
County Property Tax	$209,536
Town Property Tax	$78,595
Reading Fire District Property Tax	$19,722
Watkins Glen Central School District Property Tax	$308,872
Total Revenue	$616,725
Costs	
Schuyler County Sheriff's Office	$2,133
Schuyler County Emergency Management Office	$0
Watkins Glen Fire Department	$1,626
Schuyler County Ambulance	$0
Total Costs	$3,760
Net Fiscal Impact	**$612,965**

Source: Camoin Associates

The net fiscal impact of the Project is expected to be approximately $613,000 annually.

2012 Base Case Alternative Analysis

In previous materials submitted to the NYSDEC in 2012, the company indicated that a portion of product would be moved to and from the site via tanker trucks, which reflected market conditions at the time (the "2012 Base Case"). An independent analysis concluded that even under this higher traffic volume scenario, "the additional traffic generated by the proposed Finger Lakes LPG Storage facility is negligible and will generally not be noticeable to existing motorists or residents in the area." Under the 2012 Base Case, we do not expect the findings of the economic and fiscal impact analysis to change. The volume of the new truck traffic in this scenario is not significant enough to impose a measurable impact. Furthermore, peak truck traffic would occur during off-peak tourism months limiting the potential impact to the local tourism industry.

Review of Gas Free Seneca's Economic Development Report

Camoin was also asked to review and comment on Exhibit 6 of Gas Free Seneca's Petition entitled "*Economic Development Report*," dated January 14, 2015 and authored by Dr. Susan M. Christopherson. The report outlines the history and economic importance of vineyards, wineries and tourism in the Finger Lakes Region.

After these descriptions and on the final page of the report, the author simply states that "Based on my experience conducting economic development research in New York, it is my opinion that construction and operation of an LPG storage facility on Seneca Lake will have significant unmitigated adverse impacts on the region's economic success." However, the author does not provide us an understanding of how she arrived at her conclusion. She does not provide us any factual evidence as to the means by

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which the Project would actually cause such an impact and does not appear to discuss the probability and magnitude of any such purported impact.

For example, the author states, "The incompatibility of the Project with the surrounding natural landscape and lake-based recreation tarnishes that [tourism/winery] impact, and presents risks to the business prospects of many regional firms […]" In what way does the Project "tarnish" the natural landscape? The author does not describe the actual visual impact of the Project on the viewshed or provide any evidence that the purported visual impact will be negative or substantial. We know the visual impact is essentially nil because of factual evidence presented in the expert visual impact study referenced in our report that shows a negligible visual impact.

We know that the Project is located on a site that has been used for industrial activities including LPG and natural gas storage for decades. How is it that the Project, "[…] presents risks to the business prospects of many regional firms […]"? The author does not describe the risks in any level of detail, does not describe likelihood, frequency or magnitude, and does not provide support for her assertion that those purported risks would have a meaningful impact on businesses. We reviewed the risk profile of the project as presented in great detail in the expert Quantitative Risk Analyses and find that the actual risks of the Project as reported are negligible.

The value of wineries/vineyards/tourism on the region's economy is indisputable. However, we believe that the author fails to demonstrate with fact that the Project will have any meaningful negative impact (visual, aesthetic, noise, traffic, other) on tourism or related economic activity, and fails to provide any basis for believing the mitigation measures contemplated by the application materials and the terms and conditions of the draft permit would be ineffective. The author also ignores any positive impact that the Project could have on the region in terms of jobs, earnings and tax revenue.

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Introduction

Camoin Associates was commissioned by Finger Lakes LPG Storage, LLC (the "Company") to conduct an economic and fiscal impact analysis of its proposed LPG storage facility (the "Project") in the Town of Reading, Schuyler County, New York.

The Project will feature an LPG (including propane and butane) storage system involving the construction of two brine (salt water) ponds at two locations (referred to hereafter as the "east pond site" and "west pond site" or collectively as the "Project Site" or "Site"), a rail siding and truck loading area with offices and storage tanks, and a plant area that will transfer gas between underground storage caverns and the rail siding and truck loading area.

The Project will utilize existing underground salt caverns and the storage ponds will store a portion of the brine displaced from the caverns as LPG is pumped in. Overall, the Project will create storage capacity for 2.1 million barrels of LPG, increasing total LPG underground storage in the Town of Reading to 3.4 million barrels from approximately 1.3 million presently. This report provides an objective analysis to determine a positive or negative economic impact and quantify that impact.

To conduct an economic and fiscal assessment of the Project, we identify the potential sources of economic impacts. We rely on existing reports, analyses, testimony, and other sources including interviews to determine if each potential source of economic impact is, in fact, likely to produce an economic or fiscal impact. For each one that is expected to produce an impact, we quantify that impact using standard economic and fiscal impact methodologies. We consider the economic impact to Schuyler County and the local fiscal impacts. Please see Appendix A for additional details on the impact methodology.

Our economic and fiscal impact analysis does not attempt to quantify potential economic benefits that are speculative. For example, it is possible that the Project would enhance job retention at US Salt which would presumably benefit Schuyler County and the Town of Reading. Since our report is limited to quantifying the impact of the Project based on known and supportable data, we do not provide consideration for this potential benefit.

Potential Sources of Economic Impacts

This section identifies the *potential* (i.e., hypothetical) sources of economic impact that could be associated with the Project. These potential impacts are analyzed in more detail in subsequent sections to determine which are likely to produce an actual (as opposed to hypothetical) economic or fiscal impact, and how that impact is quantified. Such potential sources of economic impact are bulleted below followed by descriptive text.

- Visual Impact
- Noise from Operations
- Truck and Train Traffic
- Potential for Catastrophic Events
- Olfactory Impacts
- Health Impacts
- Construction Spending
- Operational Spending
- Fiscal Impacts
- Tourism Impacts

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- Property Value Impacts

Visual Impact

New development has the potential to impact the visual aesthetic of a place positively or negatively depending on how the change fits with the visual character of the community and with the nearby land use patterns. The economic impacts of this might include changes to property values (including resulting property tax revenues) and future development potential. Tourism/visitation patterns may also be positively or negatively impacted, especially in areas where scenic views are an important part of the visitor experience. Impacts to visitor spending can result in a change in employment and wages as well as sales and occupancy tax revenues.

Noise from Operations

Increased noise levels can be a nuisance to nearby property owners and others in the vicinity. This in turn makes the property less desirable, which decreases its value leading to decreased municipal property tax revenues. In terms of rental properties, it can mean lowering of rent price points. Noise can also reduce productivity of workers that are exposed to elevated levels which can distract, interrupt communication, and raise stress levels. Noise has also been associated with health impacts resulting in increased health care costs.

Truck & Train Traffic

The use of trucks and trains provides jobs for operators and loading and unloading crews. These workers spend their wages in the economy, which helps create additional jobs. It also indirectly provides jobs for those responsible for building and maintaining trucks and train cars. Truck and train traffic also produces noise that can have impacts on neighboring property values. Significant new traffic can also impact the character of a place and may cause congestion depending on the circumstances, which can impact property values and tourism levels.

Potential for Catastrophic Events

Industrial accidents such as fires, explosions, and spills can have local economic and fiscal impacts. Fiscal impacts may arise if the event requires preparation for and response to such events from municipal departments such as fire, police, EMS, and the highway departments. The fear or perception that an accident could happen might also have an economic impact as seen through an impact on property values and development patterns. Environmental contamination resulting from a catastrophic event can also have economic impacts depending on the severity.

Olfactory Impacts

Smells from industrial facilities can have economic impacts, which come largely in the form of property value impacts. Olfactory impacts are typically limited to the immediate surroundings of the source and also on downwind properties. Gas smells could also trigger a fiscal impact if they require a response by emergency service providers such as the fire department.

Health Impacts

Potential sources of health impacts (not already listed above) include the potential for air and water pollution from the facility or from the transport of LPG.

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Construction Spending

Construction of the Project may have temporary economic impacts. Jobs are created to build the Project and a portion of those wages are spent in the local economy. Purchasing construction materials locally adds new money to the local economy. Construction can also congest roads, produce noxious sounds and smells, and temporarily detract from the character of a community, which could deter local spending.

Operational Spending

Industrial operations typically require local spending on goods and services, as well the hiring of labor and thus the payment of wages. These direct impacts (employment and spending) can produce indirect impacts from business-to-business purchases and from the spending of the direct wage income locally.

Fiscal Impacts

The Project may change the value of the existing Site and potentially surrounding properties. Changes in property values have an impact on property tax revenues. New developments can also change demand for municipal services such as fire and police protection. This change in demand can potentially impact municipal costs for these types of services.

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Visual Impact

The visual impacts of the Project have been studied by C.T. Male Associates, an engineering, surveying, architecture, and landscape architecture consulting firm. We rely on their analysis ("C.T. Male Analysis"), updated in November 2014, to determine the economic and fiscal impacts of visual impacts from the Project. The analysis was performed in accordance with the New York State Department of Environmental Conservation's Program Policy DEP-00-2, Assessing and Mitigating Visual Impacts.

The analysis considered visual impacts from the roadway adjacent to each brine pond site, from Seneca Lake itself, and from across Seneca Lake. We consider these to be appropriate locations from which to study the economic and fiscal impacts of visual impacts from the Project because visual impacts at these sites have the maximum potential to produce adverse economic or fiscal impacts.

The adjacent roadways are important to consider because this is the closest proximity that general members of the public will get to the new facilities. Views from the lake are important to understand because it is a popular tourism and recreation destination while views from the other side of the lake are important because the route along the shore of the lake is frequently used by tourists. The map below shows the approximate location of the viewshed analysis points, except for the points directly adjacent to each of the sites.

Brine Pond Viewshed Analysis Points

The key findings for each of the three locations of potential visual impacts are summarized below:

- **View from adjacent roadways (NYS Route 14 and NYS Route 14A):** Visual impacts from the roadways will be mostly mitigated through the planting of native vegetation. The brine ponds themselves will not be visible from either roadway. Both sites will be "nearly completely screened" from drivers after screening vegetation has matured.
- **View from Seneca Lake:** Most of the site improvements will not be visible from Seneca Lake. When the brine ponds are constructed and the side slopes of the pond embankments are vegetated, the views from Seneca Lake are anticipated to be similar to the current views. The transfer facility will not be visible from Seneca Lake. Neither the East Brine Pond nor the West Brine Pond will be visible from Seneca Lake.
- **View from across Seneca Lake (NYS Route 414):** From Route 414, the visual impacts are expected to be similar to those from Seneca Lake. Most of the site improvements will not be visible and the brine ponds themselves will not be visible. Views are expected to be similar to current views after the side slopes of the pond embankments are vegetated.

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Also considered were the visual impact of the proposed flare tower, which will extend about 12 feet above the east pond embankment. A flare tower is a necessary safety feature and will be built only at the East Brine Pond Site. It will remove any trace amounts of LPG that may be displaced from the underground cavern along with brine when LPG is injected into the storage cavern. While there is a pilot light continuously burning, there will rarely be flares because there is usually no displaced LPG reaching the pilot light. Moreover, the flare will only be used during the injection season of product into the caverns. Finally, a shield will be installed around the flare so that it will not be visible from the lake or road.

We do not expect the visual impacts to have an economic or fiscal impact for the following reasons:

1) Much of the site development will not be visible due to local topography and vegetation:

There is a relatively minor amount of new industrial infrastructure that will be built above ground including a rail siding and truck loading area with associated offices and storage tanks. The majority of the site alterations will be in the form of the two new brine ponds. The line of sight profile analysis revealed that the ponds will not be visible from Seneca Lake or the eastern side of Seneca Lake along NYS Route 414. Once the pond embankments are vegetated, views from across the lake along NYS Route 414 will be similar to existing views.

The LPG transfer facility at the West Brine Pond Site will itself not be visible from either Seneca Lake or the eastern side of Seneca Lake along NYS Route 414. Only the cleared site may be visible from NYS Route 414. The proposed 8-foot-tall metal pump enclosure structure will not be visible from Seneca Lake, the eastern side of Seneca Lake, or from NYS Routes 14 and 14A. The flare tower is narrow and short enough not to be an imposing sight in the viewshed. The flare itself will not be visible because it will rarely be utilized and because a shield will hide it.

The analysis concluded that, “There are minimal to no potential visual impacts related to the brine pond sites (including areas cleared of trees, the brine ponds, the brine pond embankments and the brine pump enclosures) from Seneca Lake and New York State Route 414, primarily due to elevation and/or distance.”

2) For portions of the site that will be visible, effective mitigation techniques will be employed

The brine pond embankments will be seen, under certain circumstances, from Seneca Lake and Route 414 on the eastern side of the lake. These embankments, however, will not appear to be “industrial” since they will be planted with a native seed mix and will be allowed to germinate with herbaceous species. Therefore, these embankments are unlikely to stand out in any significant way in views from the lake or across the lake.

Without any mitigation, both brine pond sites will be visible from New York State Routes 14 and 14A. Mitigation efforts, however, will include “216 plantings along NYS Routes 14 and 14A at the brine pond sites and 182 plantings will be installed between the truck transfer facility and NYS Route 14A.” The C.T. Male Analysis concluded that when this vegetation is mature, “the brine ponds and truck transfer facility sites will be nearly completely screened from drivers along New York State Routes 14 and 14A.”

3) The overall visual character of the area will not be altered significantly

It is probable that drivers along NYS Routes 14 and 14A (the roadways directly adjacent to the brine pond sites) will see limited portions of the two brine pond sites, especially when leaves are off the trees. This alone is insufficient to produce an economic cost. For an economic impact to occur, we consider the potential impact on tourism and local property values.

For tourism activity to be affected by tourists driving by the brine pond sites, the visual impact would need to deter visitors from coming to the area, or otherwise decrease the amount of their spending

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during their trip through the area. First, we would expect the majority of tourists following the Seneca Lake Wine Trail to stay on NYS Route 14 based on the Seneca Lake Wine Trail published by the Seneca Lake Winery Association. The map shows that no wineries would be accessed using Route 14A by visitors following the Trail around Seneca Lake.[1] Therefore, these visitors would not pass the proposed transfer facility at the west pond site.

Second, the majority of tourists and other passers-by would only see portions of the East Brine Pond site which will "resemble a natural pond water feature that will mimic other ponds in the vicinity of the project site." Third, tourists driving along these routes will already be exposed to industrial uses, and therefore the Project's visual impacts, minor as they are, are even less significant given the characteristics of the area. For this same reason, we do not expect the Project's visual impacts along Routes 14 and 14A to significantly alter the character of the area and therefore property values will not be affected by visual impacts.

From a viewshed standpoint (from points on the lake and across the lake), for the Project to have an economic or fiscal impact related to visual impacts it would need to produce impacts that are significantly different from what currently exists. The brine pond sites belong to a larger overall viewshed area, which currently contains industrial uses and infrastructure well beyond what the Project will entail including the existing US Salt plant on the lakeshore.

Conclusion: Visual Impact

No economic or fiscal impact is expected to occur as a result of visual impacts from the Project. It is very unlikely that tourists on the eastern side of Seneca Lake or enjoying time out on Seneca Lake itself will be aware of the brine ponds. Topography and existing vegetation will conceal much of the Site from these locations and the parts of the Site that would possibly be seen will be the pond embankments which will be planted with new vegetation that will blend the Site into the natural landscape (especially during the warm weather months when tourism is at a peak). Therefore, tourism activity associated with on-lake use and the eastern side of Seneca Lake will not be impacted.

Property values on the eastern side of the lake are unlikely to diminish in value for these same reasons. The Project does not impact the existing viewshed in any meaningful way. Additionally, the viewshed from the eastern side of the lake already includes the presence of existing industrial uses with a far more pronounced visible aspect.

Noise from Operations

We examined the noise impacts associated with the Project to determine if any noise from the Project will have an economic or fiscal impact. We relied on a Sound Study prepared by HUNT Engineers, Architects & Land Surveyors (hereafter referred to as the "HUNT Study"), a surveying, engineering, and architectural consulting and design firm. The study was prepared in 2011 and updated in 2013. It was done in accordance with the New York State Department of Environmental Conservation's Noise Program Policy DEP-00-1, Assessing and Mitigating Noise Impacts.

The sources of noise from the Project include the following:

- Truck and rail unloading activities
- Gas injection pumps
- Brine injection pumps

[1] Based on wineries shown on the Seneca Lake Wine Trail map available online at www.senecalakewine.com (accessed 10-24-2014)

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- Emergency fire pumps

For any of these elements to have a significant economic or fiscal impact, sound levels would need to satisfy each of the following three criteria:

1) Be noticeably greater than existing ambient sound levels,

2) Reach an objectionable level at an off-site location(s), and

3) There must be a nexus between the off-site location where that objectionable sound level is heard and an economic or fiscal impact (e.g., an objectionable sound level that can only be heard from an unused or inaccessible portion of a neighbor's property would not meaningfully decrease that property's value).

The HUNT Study examined current sound levels and compared them to what future sound levels will be once the Project is complete and operational. It found that "the majority of activities would not cause objectionable increases to the existing ambient sound levels." Only the injection pumps were found to have the potential to cause a "noticeable increase in ambient levels." However, that scenario is only "without consideration for natural attenuation and proposed mitigation." When the proposed building enclosure and berms were factored in, it was determined that "the noise would be decreased to an unnoticeable level." **Therefore, criteria #1 and #2 as stated above are not satisfied and no economic or fiscal impact is anticipated.**

We also consider further three possible scenarios of potential concern:

- **Noise from Increased Rail Traffic:**
  LPG will be moved by rail. The number of rail cars (both directions) is expected to average about 6.8 cars per day. Most new rail traffic will consist of these cars being attached to existing trains. At the most, only one new train trip per day would be generated as a result of the Project. The rail line is currently in active use for freight transport. US DOT data indicates that between 2 and 4 trains use the existing Norfolk Southern rail line daily.[2] One additional train therefore does not constitute a noticeable increase in sound levels over current levels. **No economic or fiscal impact is anticipated.**

- **Objectionable Sound Levels at Local Motel:**
  One of the closest business neighbors to the Site (approximately ¼ mile) is an existing motel. The study placed a sound receptor at the site of the motel to determine existing ambient sound levels. This was compared with expected new sound levels at the hotel as a result of new equipment as part of the Project. The study concluded that, "The increase over the estimated night time level at the hotel does not exceed noise levels to the point of being intrusive."

  A supplemental analysis prepared by HUNT and submitted to NYSDEC found that with a noise barrier and accounting for distance and vegetation, the Project would increase ambient sound levels by less than six dB(A), which is the threshold for evaluating further mitigation methods under NYSDEC's Noise Policy. The supplemental analysis concluded that, "Incorporating these accepted mitigation methods shows that the proposed equipment will not result in sound levels that are intrusive to the motel or its occupants..." Therefore there is no reason to anticipate that the motel will experience a loss of customers or a decrease in its value because of increased sound levels. **No economic or fiscal impact is anticipated.**

[2] Data taken from U.S. DOT's crossing inventory information for the two closest rail crossings to the proposed project site (Abrams Rd. and Chase Rd.)

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- **Sound from Fire Pumps on Lake:**
  The Project includes the addition of fire pumps on the shore of Seneca Lake. According to the Hunt Study, the location "can be expected to have an ambient sound level of around 50 dB(A)." The study notes that fire pumps have an operating sound level of 84 dB(A). These pumps, however, only need to be operated in emergency situations and during twice-yearly testing. It is expected that testing will occur in the middle of the day "to limit any impacts the noise level increase would have on the lake." Due to the infrequency of fire pump operation it is not expected that any economic or fiscal impact would result. **No economic or fiscal impact is anticipated.**

Conclusion: Noise from Operations

No economic or fiscal impact is expected to occur as a result of increased sound levels from the Project. The sound analysis completed by HUNT, based on conservative assumptions, found that sound levels will be effectively mitigated and non-objectionable.

Truck and Train Traffic

New truck and train traffic will be minimal as a result of the Project because the majority of product movement will occur by underground pipeline. As shown in the table below, there will be no new movement of product by truck into or out of the area as a result of the Project. Propane is distributed to local consumers today by truck, and this truck traffic will continue after the Project is completed. Truck traffic associated with local propane distribution will be the same current levels because local demand for propane itself is not increasing as a result of the Project. Therefore, there will be no new truck traffic to the area and no economic impact from new truck traffic.

Product Movement (Inbound & Outbound)			
	Truck	Train	Pipeline
Butane	0%	100%	0%
Propane	0%	5%	95%

Source: Finger Lakes LPG Storage, LLC

All butane and a small proportion of propane will be moved by rail. As discussed in the noise impact section, the average number of daily new rail *cars* expected as a result of the Project is 6.8. Most new rail car traffic will consist of cars being attached to existing freight trains. At the most, only one new train trip per day would be generated as a result of the Project, Therefore, there is no reasonable expectation of a negative economic impact associated with noise or other disturbance impacts from increased train traffic because the rail line is already an active freight train corridor.

The potential economic and fiscal impacts associated with catastrophic events involved with the movement of product, such as train derailment or pipeline accidents, are discussed further in the Catastrophic Events section of this report.

Conclusion: Truck and Train Traffic

No economic or fiscal impact is expected to occur as a result of increased new traffic due to the Project. There will be no new truck traffic generated as a result of the Project and new rail traffic will be negligible relative to existing conditions. A positive economic impact will likely be associated with jobs related to product movement along rail. These are considered in the "operations" section of this report.

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Potential for Catastrophic Events

As with many industrial projects, accidents or catastrophic events have the potential to inflict negative economic impacts should they occur. Our analysis of potential economic impacts associated with such catastrophic events relies on previously completed analyses and existing research of the risks of the Project. These sources are described in additional detail in this section.

To understand the risks that are likely to generate economic or fiscal impacts we consider the risks that, in our estimation, could reasonably be expected to occur. All potential risks associated with the Project carry a certain probability. For each potential risk, we examine that probability to determine whether an economic or fiscal impact is likely to be generated. We do not attempt to calculate the economic or fiscal impact of near-zero probability events because the purpose of this analysis is to estimate the likely economic and fiscal impacts from the Project.

This analysis examines on-site risks at the Project Site itself and off-site risks associated with moving product by truck, rail, and pipeline.

On-Site Risks

Cavern Collapse & Lake Contamination

Two potential risks that have been identified and analyzed are the potential collapse of a salt cavern used for storing LPG and the contamination of Seneca Lake. Our understanding of this risk is derived from a technical assessment of the cavern suitability prepared by Dr. Samuel W. Gowan, analyses performed by Quest, approval given by the New York State Geologist, a recent Federal Energy Regulatory Commission (FERC) analysis of the same geology and risk issues, and a memorandum from the geologists who analyzed the suitability of the caverns.

Dr. Samuel W. Gowan, CPG of Alpha Geoscience prepared an independent analysis of the suitability for storage of LPG in Gallery 1 and Gallery 2 (the two project storage caverns). The analysis confirmed the suitability of the caverns for LPG storage. Below are relevant conclusions excerpted from the analysis:

- “Long term cavern pressure tests in Gallery 1 and Gallery 2 confirm that the caverns and associated faults, fractures, salt beds and shale beds do not leak”
- “The long term storage of LPG and natural gas in nearby Arlington Galleries 1 and 2 confirm that the geologic conditions are suitable for containment of LPG without leakage”

Regarding the potential for cavern collapse, the report concluded that “The extensive set of technical data for the proposed galleries and the history of successful use of neighboring galleries for LPG and natural gas storage lead to the conclusion that catastrophic structural failures of the caverns and associated wells are not likely.”

It should also be noted that the report examined the potential for catastrophic failure from seismic events and found that the probability is low due to “the fact that the faults that have been documented in the area are healed and apparently have not been active since the Appalachian Orogeny, which occurred approximately 225 million years before the present...”

Overall Dr. Gowan concluded that “within a reasonable degree of scientific certainty, that LPG can be stored successfully at Finger Lakes Gallery 1 and Gallery 2 without leakage to the environment or catastrophic failure of caverns and/or wells.”

Quest examined incidents involving NGL/LPG storage in salt formations in the U.S. and Canada to estimate salt cavern failure frequencies. Based on a review of about 1,125 NGL/LPG salt caverns in service and three major incidents involving salt cavern storage that presented a public risk of fatality or

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injury, a major incident rate of 5.93 x 10^{-5} per cavern per year was calculated. This frequency translates to a risk of one chance in 16,875 per year per cavern or one chance in 8,405 when the two LPG caverns of the Finger Lakes LPG project are considered.

In our analysis, we are concerned not just with injury, but also property damage, business interruption costs, perceptions of safety, etc. Therefore we also considered the additional 7 recorded incidents that involved evacuations and/or on-site property damage. As shown in the table below, the two Finger Lakes LPG storage caverns carry an annual chance of one in 2,531 for a major or catastrophic incident.[3]

Probability of On-Site Major/Catastrophic Cavern Incident	
Number of NGL/LPG Salt Caverns in Service	1,125
Years of Service per Cavern	45
# of Cavern-Years	50,625
Major Incidents	10
Event Frequenjcy per Cavern-year	1.98E-04
Annual Major/Catastrophic Risk Chance of One in…	5,063
2-Cavern Annual Major/Catastrophic Risk Chance of One in…	2,531

Source: 2015 Quest QRA Report, Camoin Associates

We also considered further evidence of the safety of the project's cavern storage. In 2013, New York State Acting Associate State Geologist Andrew Kozlowski analyzed the Project's applications materials including studies of the Site geology and issued his approval. The following is an excerpt from his letter submitted to the Director of the New York State Department of Environmental Conservation on March 15, 2013. The comments indicate that an independent review by the New York State geologist found that there is unlikely to be a cavern collapse.

> *At the time of this application there does not appear to be any geological reason to deny their request to utilize the geologic formations specified for the storage of liquefied petroleum gas. Their demonstration of both cap rock and cavern integrity is complete, and with a properly developed monitoring program, Finger Lakes' proposed use of the Salt Point caverns is geologically sound. Further, in our review of the application materials, it has been demonstrated that the caverns in this salt formation have a longstanding operational record as a gas storage facility without any geologic evidence of incompatibility for this intended purpose.*
>
> *Based on my reviews of the application materials and subsequent filings, I hereby grant approval of the project based on my findings that the project will have no adverse impact on the existing geologic environment.*

We also consider the fact that the NYSDEC issued a draft permit for the Project on November 10, 2014. The draft permit would allow for use of both caverns the Project had proposed to use (Gallery 1 and Gallery 2), with specific conditions. With respect to the integrity of the existing brine-filled caverns, the conditions described in the draft permit generally outline routine monitoring actions that will be required. The draft permit is a strong indication that the Department believes the Project can be permitted in the future and that the information reviewed by the Department so far has not provided any reason to doubt the integrity of the cavern geology.

Furthermore, we consider the analysis and approval by the Federal Energy Regulatory Commission to Arlington Storage Company, LLC to convert and use nearby underground salt caverns for natural gas

[3] It should be noted that Quest's 2012 QRA presented a cavern failure rate of 1.0 x 10^{-5}. However, because the figures presented in the 2014 Quest QRA lead to a higher calculated probability of risk, we use the higher probability figures in the interests of being conservative.

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storage. This analysis is relevant because the geology of the caverns is similar to that of the Project and the risks associated with that geology are similar.

Overall, the FERC analysis and determination found that the salt caverns proposed for use are suitable for natural gas storage concluding that "there will be no significant impact on environmental resources due to geologic hazards or from the geologic framework present in the Gallery 2 Project area." The geologic framework reference is the same that pertains to the Finger Lakes LPG Storage Project. While it should be noted that cavern integrity is examined on a cavern by cavern basis, the determination indicates that FERC does not have any serious concerns regarding the geology of the caverns. It should also be noted that the (i) NYSDEC, acting as a cooperating agency, provided data and recommendations to the FERC in the proceeding, and (ii) LPG and brine are stored underground at similar pressures, whereas natural gas is stored at higher pressures than LPG or brine.[4]

A memorandum provided by the geologists that studied the geology in and around the underground salt caverns responded to specific concerns raised in public comments. The memo indicates that salt is impermeable by nature and will not allow the migration of LPG or brine. Pressure in the caverns will be consistent with current pressure because the pressure will be the same regardless if it is LPG or brine in the cavern. Furthermore, mechanical testing has shown that the caverns do not leak.

Additionally, the geologists indicate that there is no threat to the caverns from any seismic activity. The Seneca Lake Fault, one specific concern brought up in public comments, has no seismicity associated with it and there are no major tectonic structures of regional extent that are considered active or potentially active. Overall the geologists conclude that concerns raised in public comments "do not in any way raise any concern regarding the suitability of the underground salt caverns to store LPG in a safe, reliable and environmentally sensitive manner."

We also considered the 2012 Seneca Lake Watershed Management Plan to see if any risk of lake contamination warranted further analysis as part of the economic impact analysis. The plan states, "The Watkins Glen facility has abandoned salt caverns filled with salt brine that could be used to store liquid petroleum and natural gas. This proposed use provides some concerns as the liquid petroleum or salt brine could contaminate the Lake and its watershed." The Watershed Management Plan also identifies 16 existing chemical bulk storage facility permits in the watershed with five falling in Schuyler County. An additional 166 active, regulated and smaller unregulated petroleum bulk storage permits are in the watershed.

The plan does not identify any specific threat from the storage of LPG. It concludes that further assessment is needed, "New industries and activities should be investigated to assess their impact on the watershed. For example, the proposed storage of energy products (propane and natural gas) in the abandoned salt caverns near Watkins Glen and drilling for shale gas loom close on the horizon."

Based on the information available, as discussed above, we believe a cavern collapse or contamination of the lake to be a near-zero probability event. Therefore no economic or fiscal impact associated with such is anticipated.

[4] According to the report prepared by Dr. Gowan, the maximum authorized pressure at Arlington Gallery 1 and 2 is 0.9 psi/ft compared to the maximum proposed operating gradient of 0.66 psi/ft at well 58 and 0.61 psi/ft for well 33, and the maximum allowable pressure gradient of 0.75 psi/ft at Wells FL1 and FL2. The result is "less stress on the caverns at Finger Lakes Galleries 1 and 2 from the storage of LPG than on Arlington Gallery 1, which has been storing natural gas without apparent incident since some time after 1996 and prior to 2002."

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Other Potential On-Site Risks

The most likely on-site catastrophic events are those that have occurred at similar facilities in the past. The types of catastrophic events that have occurred with other salt cavern storage facilities have been mostly related to the failure of the well or well casing, failure of above ground infrastructure (valve, pipes, wellhead or compressor units), loss of cavern capacity due to operational pressures being too low to maintain cavern walls, and the overfilling of caverns. A review of accidents at eight salt cavern storage facilities found that none of the accidents that occurred are likely at Finger Lakes' facility.

We do not expect there to be any economic or fiscal impacts from the Project due to on-site accidents.

Product Movement Risks

Quest Consultants Inc., an independent expert in quantifying risks associated with energy and petrochemical projects, was hired by the Company to conduct a quantitative risk analysis for the transportation aspects of the Project. The Quest analysis determined, among other things, the probability of a major or catastrophic release of product from pipelines and rail cars. We rely on these probabilities in our determination of the economic impact from product movement risks.

Pipeline

The Project will add one half mile of new pipeline through which propane will be transported to and from the site. To reach the new section of pipeline, incoming and outgoing propane will continue to be transported through existing pipelines; however, moving new product through those existing pipelines does not alter the existing risk profile of those pipelines (Source: Interview with Quest. Pipelines, whether active or idle, maintain product and constant pressure, so volume flow does not affect leak frequency.) Therefore, in analyzing the Project, we consider only the incremental change in pipeline risks represented by the new one half mile of pipeline.

As shown in the table below, the probability of a pipeline release is 1.57 x 10^{-3} per mile per year. The distribution of those releases is also presented in the table below.

Probability of Pipeline Releases and Event Distribution	
Frequency of a pipeline release per mile per year	1.570E-03
Fraction of ruptures (catastrophic)	0.3669
Fraction of major releases	0.2427
Fraction of punctures	0.1713
Fraction of leaks	0.2503

Source: Quest Report, Interview with Quest, Camoin Associates

Based on the annual frequency of a pipeline release per mile above, new Project pipeline has an annual release chance of one in 1,274. As shown in the event distribution table above, major or catastrophic releases account for 61% of all release events. This means that the annual major or catastrophic release chance is one in 2,090.

Probability of Crestwood Pipeline Events (Schuyler County)	
Frequency of a pipeline release per mile per year	1.57E-03
Number of new pipeline miles	0.5
Annual probability of any release (new 0.5 mile Crestwood pipeline)	7.850E-04
Annual release chance of one in…	1,274
% of releases that are major or catastrophic	61%
Annual probability of a major/catastrophic release (Crestwood pipeline)	4.785E-04
Annual major/catastrophic release chance of one in…	2,090

Source: Quest Report, Interview with Quest, Camoin Associates

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Furthermore, a majority of the pipeline will be located on the Company's property, minimizing even further the chance of imposing an economic impact on third parties.[5] Because a major or catastrophic pipeline release on or off the Site is a near-zero probability event, we do not consider it a source of economic impact.

Rail

Product will also be moved to and from the Site by rail. The following table contains the expected frequency of releases and BLEVEs per railcar-mile[6]. Catastrophic events are represented by the BLEVE of a railcar, defined as boiling liquid expanding vapor explosion. Quest explains a BLEVE as "typically a secondary event that is caused by an ignited release of flammable material, where the flame impinges on that of another vessel, eventually causing it to rupture catastrophically. The impinging flame provides ignition for the released material, and a fireball results."

Probability of Railcar Releases and Event Distribution	
Frequency of release per railcar-mile	2.023E-08
Frequency of a BLEVE per railcar-mile	3.287E-10
Fraction of releases that are BLEVEs (catastrophic)	0.0162
Fraction of releases that are 3-inch holes (major)	0.0411
Fraction of releases that are 1-inch holes (puncture)	0.0455
Fraction of releases that are 1/4-inch holes (leak)	0.8971

Source: Quest Report, Interview with Quest, Camoin Associates

As shown in the table below, there will be 105 annual railcars of propane and 1,680 railcars of butane. These railcars will travel approximately 12 miles on tracks from the edge of Schuyler County to the Site and back. The total number of annual railcar miles is therefore 21,420 (we only consider loaded railcars). According to Quest, the probability of a release from a railcar is 2.023×10^{-8} per railcar mile. This means that there is an annual release chance of one in 2,310 in Schuyler County.

Similar to pipeline releases, not all railcar releases would be major or catastrophic. As shown in the event distribution table above, catastrophic events account for only 1.6% of railcar releases while major events account for 4.1% of railcar releases (5.7% together). As shown in the table below, the annual chance of a BLEVE in Schuyler County is one in about 142,450. Overall, there is an annual major or catastrophic release chance of one in approximately 41,000 in the County. Furthermore, the probability that such an event would occur in a populated area (thus representing a threat to property and lives) is actually much smaller given the rural nature of most of the rail line in the County.

[5] We note that a more narrow definition of acceptable risk was used in the Quest Report, specifically related to the potential for an event that would cause a fatality. For pipeline transport, Quest calculates such probability of 1 in 66,670 but only if someone were to stand directly above the pipeline continuously for an entire year, as an illustration of the maximum risk. Quest notes a less than one in one-million chance of a fatality for areas further away than 250 feet of the pipeline (again, assuming the individual stood continuously in one spot for a year). See Quest page 1 and 2. We used a much broader definition of the level of acceptable risk because of concerns about property damage, business interruption costs, perceptions of safety, etc.

[6] The Quest Report noted that 40 release incidences have occurred for STCC 29121 (which includes LPG and similar materials) between 2000-2012, as reported by the Surface Transportation Board, compared to 1,977,462,212 railcar-miles traveled in that time period for a frequency of 2.02×10^{-8} See Quest page 29.

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Probability of Crestwood Railcar Events (Schuyler County)	
Number of propane railcars per year	105
Number of butane railcars per year	1,680
Total number of railcars per year	1,785
Total number of miles traveled in Schuyler County by rail	12
Total number of railcar miles per year	21,420
Annual probability of any release (Crestwood railcars)	4.333E-04
Annual release chance of one in…	2,310
Annual probability of a railcar BLEVE (Crestwood railcars)	7.020E-06
Annual BLEVE chance of one in…	142,450
% of releases that are major or catastrophic	5.7%
Annual probability of a major/catastrophic release (Crestwood railcars)	2.44E-05
Annual major/catastrophic release chance of one in…	40,990

Source: Quest Report, Interview with Quest, Camoin Associates

As shown, the risk of a catastrophic or major release is exceedingly remote, such risk further mitigated by the relatively undeveloped environs of the rail line[7]. Because this represents a near-zero probability event, we do not consider it a source of economic impact[8].

Conclusion: Potential for Catastrophic Events

No economic or fiscal impact is expected to occur as a result of on-site or product movement risks. The Site has been vetted and approved by numerous experts and regulatory officials for its intended use and there does not appear to be any meaningful risk of a catastrophic event at the Site to disrupt local economic activity. Furthermore, catastrophic events related to the transport of product to and from the Site appear to have a near-zero probability of occurrence.

Olfactory Impacts

Potential sources of noxious smells were considered in our analysis. It is our understanding that no odors will be emitted from pumps, flanges, or valves. The brine pond themselves will not produce odors because only salt water will be stored in the ponds. The only potential source of odor on the site is from mercaptan, which is automatically injected into trucks or rail cars when they are loaded with propane. This process uses a sealed system to inject the mercaptan. Therefore, there is unlikely to be any nuisance "gas" odors from operations on-site. As discussed previously, there will be no new truck traffic and therefore odors associated with truck exhaust will be nonexistent.

[7] Again, we note that a more narrow definition of acceptable risk was used in the Quest Report, specifically related to the potential for an event that would cause a fatality. For rail transport, Quest calculates such probability of 1 in 5,000,000 but only if someone were to stand directly adjacent to the rail line continuously for an entire year. See Quest page 1 and 2. We used a much broader definition of the level of acceptable risk because of concerns about property damage, business interruption costs, perceptions of safety, etc.

[8] By way of comparison, catastrophic risks such as floods are measured as the expected number of times in a given 100 year period a qualifying flood event will occur. Flood maps delineate the 100-year flood plain most typically, occasionally noting the 500-year flood plain. Development is encouraged outside the 100-year flood plain (or 500-year flood plain) because the risk of loss is considered acceptable at levels below the 100-year (or 500-year) occurrence frequency.

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Conclusion: Olfactory Impacts

No economic or fiscal impact is expected to occur as a result of noxious odors from the Project. The brine ponds will contain only salt water and the only potential source of noxious odors is mercaptan, which is confined to a sealed system.

Health Impacts

The potential health impacts associated with the Project were examined to see if any economic or fiscal costs will be associated with the Project. We considered possible air pollution and hazardous chemicals in our analysis as the potential sources of health impacts. Catastrophic events are discussed separately in this report. There is no expectation that the Project will impact air quality. There will be no new truck traffic so there will be no new air pollution from trucks associated with the Project. As previously mentioned, product will be moving by rail and pipeline, except local propane delivery by truck that will continue at the same level it is currently.

It is also our understanding that the facility should not cause any health problems because there will be no exposure to the chemicals related to the facility's processes. Therefore, no health impacts or associated economic impacts are anticipated as a result of the Project.

Conclusion: Health Impacts

No economic or fiscal impact is expected to occur as a result of health impacts from the Project. According to New York State, neither air pollution nor on-site chemicals will result in any adverse health impacts.

Construction Spending

Construction of the Project will inject money into the local economy while providing local employment opportunities. The Company has made $35.4 million of capital expenditures on the Project through September 30, 2014, and the Company expects to make an additional $17.4 million of capital expenditures to complete the Project over a 12-month construction timeline. Additionally, about 50 construction jobs will be created as a result of the Project. Local contractors will be used for the construction phase of the Project so all construction jobs will be available to residents of the region.

We use the EMSI economic impact model, which allows the analyst to break down the total direct spending by NAICS code to get an accurate read for how one dollar spent in a specific industry sector multiplies throughout the local economy in terms of sales, jobs, and earnings. For additional information on this methodology see Appendix A. We consider the economic impact specifically to Schuyler County.

As shown in the table below, construction will generate 8 additional jobs in the economy for a total of 58 jobs. Jobs are expressed as full-time-equivalents (i.e., one full time job for one year). Total earnings of those jobs are expected to total $2.27 million. The total sales impact in Schuyler County from construction will be approximately $18 million. It is important to note that construction impacts are one-time. That is, the 58 jobs, $2.27 million in earnings, and $18 million in sales will be realized only during the year of construction activity.

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One-Time Construction Impacts: Schuyler County			
	Direct	Indirect	Total
Jobs	50	8	58
Earnings	$2,046,993	$225,169	$2,272,162
Sales	$17,400,228	$609,212	$18,009,440

Source: Direct impacts provided by Finger Lakes LPG Storage, LLC; Indirect impacts modeled by Camoin Associates using EMSI

The Company is considering multiple construction labor options. It is possible that spending on construction labor could be as much as $1.5 million higher than in the above analysis. This would have a greater economic impact than presented. If labor expenditures were to increase by $1.5 million, then an additional six indirect jobs (the equivalent of six full-time jobs for one year) would be created off-site in Schuyler County. As with above, these jobs would be a one-time impact. Along with those jobs would be an additional $160,300 in indirect earnings.

Conclusion: Construction Impacts

Project construction will generate a one-time annual economic impact of 58 jobs, $2.27 million in earnings, and $18 million in sales.

Operational Spending

The annual operations of the Project will generate approximately 11 new full time jobs on-site. Jobs include a transportation clerk, 8-10 operators, and a plant supervisor. The annual wages and salaries of those positions is expected to be about $491,000. A portion of these wages will be spent in the local economy, which will support local jobs and businesses. Note that our analysis focuses on base salaries and wages and that the 11 new full time employees will be eligible to receive annual performance bonuses, the actual amount spent in the local economy by these 11 new full time employees may be significantly higher than the $491,000 estimate.

The table below shows the employment impact of the Project. Note that the Company estimates 8-10 full time operators. For the purposes of our analysis we assume there will be 9 operators, the midpoint of that range.

Annual Employment Impact from Operations				
	Jobs	Wages/Salary Per Worker	Average Annual Wage/Salary per	Total Wages/Salary
Transportation Clerk	1	$18/hour	$32,760	$32,760
Operator	9	$37,440 - $47,800	$42,620	$383,580
Plant Supervisor	1	$75,000	$75,000	$75,000
Total	11			$491,340

Source: Finger Lakes LPG Storage, LLC

Similar to the construction impact analysis above, we use the EMSI economic impact model, which allows the analyst to break down the total direct spending by NAICS code to get an accurate read for how one dollar spent in a specific industry sector multiplies throughout the local economy in terms of sales, jobs, and earnings. For additional information on this methodology see Appendix A. We consider the economic impact specifically to Schuyler County.

As shown in the table below, operations will generate an annual economic impact of 17 jobs including 6 off-site (indirect) jobs generated in Schuyler County. The Project will generate approximately $684,000 in annual earnings in the County. Approximately $193,000 of those earnings are the indirect impact of the Project as wages paid to on-site (direct) workers are spent and circulated through the local

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economy. The indirect impact of the Project on Schuyler County also includes a sales (economic output) impact of $507,000 annually.

Annual Impact from Operations: Schuyler County			
	Direct	Indirect	Total
Jobs	11	6	17
Earnings	$491,340	$193,052	$684,392

Source: Direct impacts provided by Finger Lakes LPG Storage, LLC; Indirect impacts modeled by Camoin Associates using EMSI

Conclusion: Operational Spending

Project operations will generate an annual economic impact of 17 jobs, $684,392 in base earnings, and $507,000 in indirect sales in Schuyler County.

Fiscal Impact

The potential positive and negative fiscal impacts of the Project include changes in property tax revenues and costs associated with local municipal services. We consider changes to the property value of the Site itself and any possible changes to the value of surrounding properties. To understand potential new municipal costs, local municipal service providers were interviewed including officials from the Schuyler County Sheriff's Office, Watkins Glen Fire Department, and Schuyler County Office of Emergency Services.

Property Tax Revenue

The Project Site will be taxed at its full assessed value which, in the case of the Town of Reading, is the same as its market value. Its final assessed value after completion is estimated to be $25 million. To estimate the property tax revenue attributed to the Project, we apply the existing property tax rates for the applicable taxing jurisdictions to the future assessed value of the Site. As shown in the table below, approximately $617,000 in annual property tax revenue will be attributed to the Project. The Project will receive no exemptions or tax abatements.

Annual Property Tax Revenue		
	Rate	Revenue
County	8.381446	$209,536
Town	3.143795	$78,595
Reading Fire District	0.788868	$19,722
Watkins Glen Central School District	12.354890	$308,872
Total	24.668999	$616,725

As discussed in previous sections, there is not anticipated to be any property value impact to adjacent or nearby properties from noise, visual, traffic, or other impacts. Due to the rural nature of the Site and characteristics of surrounding properties, any theoretical property tax loss due to the decline of property values would be negligible with respect to the anticipated new property tax revenue.

Municipal Services

Significant development projects can cause the cost of providing municipal services such as police and fire protection to increase. We considered four service providers that could potentially be impacted. These include the Schuyler County Sheriff's Office, the Watkins Glen Fire Department, the Schuyler County Emergency Management Office, and Schuyler County Ambulance. Interviews were conducted with all service providers except for Schuyler County Ambulance, which declined to be interviewed. Letters from each of the interviewed service providers can be found in Appendix B.

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Schuyler County Sheriff

The Schuyler County Sheriff's Office is responsible for providing police services in the Town of Reading. Sheriff William E. Yessman, Jr. was interviewed as part of this analysis to determine if there will be any increased costs to the Sheriff's Office as a result of the Project. The following is a summary of our conversation with the Sheriff.

> There may be increased costs to the Sheriff's Office due to a potential increase in protests at the Project Site. Existing protests have occurred at a rate of approximately three per 18 months (i.e., an annual rate of 2 per year). Four females were arrested across the three protests. The Sheriff's office has an expense when female protestors are convicted because such female convicts have to be housed in non-County owned facilities. The cost is approximately $85 per day for an average of 10 days for each convicted female protestor.
>
> Overtime costs associated with each protest total approximately $1,000 per event. This is largely due to extra staff time needed to respond, transport arrested protestors for processing, and transport convicted female protestors to a non-local facility for boarding during their sentence.

It is likely that protests will actually cease once the expansion project is complete. For example, at the Stagecoach Natural Gas Storage Facility in Owego, NY, protests occurred prior to approval and ceased following approval. In the interests of taking a more conservative approach, we will assume that protests will in fact increase after the Project is complete. For the purposes of this analysis, we assume that protests will increase by 50%.

As shown in the table below, the total average cost to the Sheriff's Office per protest is approximately $2,133.

Average Cost per Protest	
Females Arrested Per Protest	1.33
Cost per Female Convict	$850
Cost per Female Per Protest-Female Convicts	$1,133
Overtime Cost Per Protest	$1,000
Average Cost per Protest	$2,133

Source: Schuyler County Sheriff's Office; Camoin Associates

To estimate the percent increase in protests we assume that the number of protests will increase by 50%. We consider this estimate to be on the high end and therefore it is more likely to overestimate the new cost to the Sheriff's Office.

Increased Annual Protest Cost	
Average Cost per Protest	$2,133
Protests per Year	2.00
Annual Protest Cost	$4,267
% Increase in Annual Protests	50%
Increased Annual Protest Cost	$2,133

Source: Camoin Associates

As noted by the interviewee, no other costs are anticipated.

Schuyler County Emergency Management Office

The Emergency Management Office is tasked with overseeing, assisting, and coordinating the fire service, emergency medical service, hazardous material response, 911 service, and disaster

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preparedness and response activities throughout Schuyler County. Emergency Management Coordinator William Kennedy was interviewed to determine if there will be any increased costs to the Emergency Management Office.

The Emergency Management Office currently has plans in place for LPG storage and transmission through pipelines and hazardous materials by rail. Railroad related planning efforts specific to LPG are currently underway for the entire County. To date, the County has not identified any specific equipment, operational, or other capital cost that would occur as a result of the Project. As planning continues it is possible that new costs could be identified.

After the Project is completed, the Emergency Management Office does not anticipate any significant additional planning-related costs to the County. Therefore, based on information provided by the Emergency Management Office, we do not expect there to be any additional costs associated with the Project.

Watkins Glen Fire Department

The Watkins Glen Fire Department ("the Department") is responsible for providing fire protection and emergency response services to the Village of Watkins Glen, Town of Dix, and the Town of Reading, including the Project Site. Fire Chief Judson Smith was interviewed as part of the analysis to determine if there will be any increased costs to the Department as a result of the Project. The following is a summary of the interview we conducted and the letter provided to us by the Fire Chief.

> The Department occasionally responds to calls around the existing facility, but the facility personnel take care of any issues on the Site itself. It is not anticipated that the frequency of these responses would increase as a result of the Project. The Fire Department also serves as EMS first responders. There are no anticipated new costs for EMS services provided by the Fire Department as a result of the Project.
>
> According to the Department, there would be an increased cost to purchase a larger capacity foam induction system if any new or additional methanol is stored on-site. (We note that, based on comments from the Project sponsor, the Project will not involve any new or additional methanol on-site. Therefore, there will be no methanol-related cost to the Fire Department.)
>
> There may be an increased cost to the Department associated with training for train-related accidents because the Project would involve the movement of LPG via rail car. Fire Department personnel receive training as recruits in hazardous and flammable firefighting. However, it can be hard to keep that training up to date for personnel who might be involved in a response to a train derailment. State facilities in Montour have the only LPG-type simulation equipment available in the area; however, it is very hard for the Fire Department to book that equipment for regular training exercises. Because of that difficulty, it would be helpful for the department to have its own flammable gas training simulator so that fire department personnel could use the simulator to train. The cost of a new flammable gas training simulator is estimated to be between $10,000 and $25,000.

We do not believe that this simulator is actually required for the Project, given the fact that flammable materials are already transported via rail in the Town and already exist in bulk storage elsewhere in the Town. However, for the purposes of being conservative in our analysis, we instead assume that the training simulator is a necessary cost as a result of the Project. To determine the annual cost of the simulator, we calculate the annual bond payment that would be required to purchase the equipment. We assume a 30-year bond issued at 5%. In the interest of being conservative, we assume the

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equipment will cost $25,000. As shown in the table below, the annual cost of the simulator is approximately $1,626.

Annual Cost of Simulator	
Simulator Cost	$25,000
Bond Rate	5%
Annual Bond Payment	$1,626

Source: Camoin Associates

Schuyler County Ambulance

Schuyler County Ambulance is a not-for-profit business that does not receive funding from any local or state government according to the Watkins Glen Chamber of Commerce. Funding for the operation comes from patients who are transported and private contracts.[9] As no increase in calls is anticipated and any such costs would be reimbursed by private insurance payments, there would be no increased municipal cost associated with increased demand for EMT services provided by Schuyler County Ambulance.

Conclusion: Fiscal Impact

The net fiscal impact of the Project is expected to be approximately $613,000 annually. Property tax revenues will total approximately $617,000 annually while new municipal costs generated as a result of the Project are estimated to be approximately $3,760 annually. The table below breaks down the allocation of costs and revenues, as discussed in the above analysis.

Summary: Net Fiscal Impact	
Revenues	
County Property Tax	$209,536
Town Property Tax	$78,595
Reading Fire District Property Tax	$19,722
Watkins Glen Central School District Property Tax	$308,872
Total Revenue	$616,725
Costs	
Schuyler County Sheriff's Office	$2,133
Schuyler County Emergency Management Office	$0
Watkins Glen Fire Department	$1,626
Schuyler County Ambulance	$0
Total Costs	$3,760
Net Fiscal Impact	**$612,965**

Source: Camoin Associates

Impact on Tourism

In this section we take a look at the historical performance of the tourism industry in Schuyler County to see if there have been any clear changes in its trajectory related to the opening or closure of industrial facilities. The key dates to consider are A) 1984, which is when US Salt ceased storing propane on site after a 20-year period and Enterprise placed its Watkins Glen LPG storage facility into service, and B) 1997, which is when the Seneca Lake Natural Gas Storage Project, a natural gas storage facility located at the US Salt complex, was placed into service. The Watkins Glen LPG storage facility and the Seneca

[9] Watkins Glen Chamber of Commerce Website < http://watkinsglenchamber.chambermaster.com/list/member/schuyler-ambulance-876> (accessed 10-24-2014)

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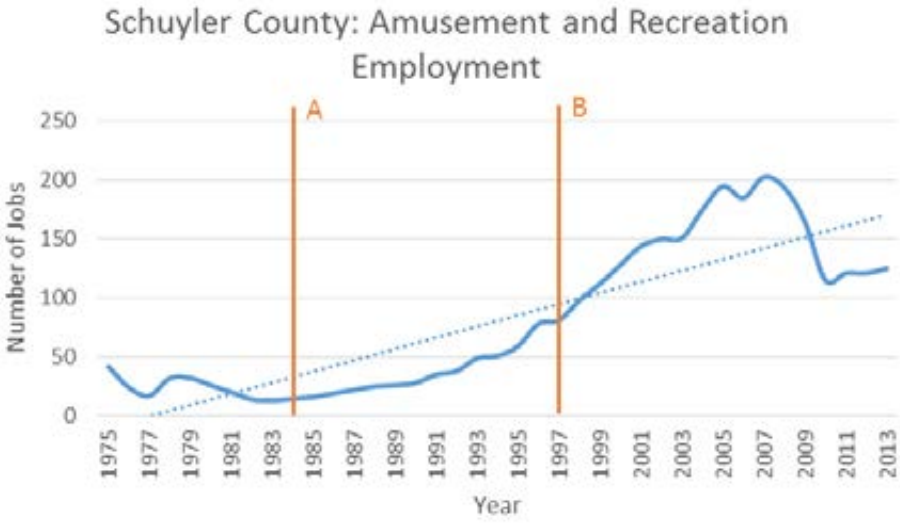
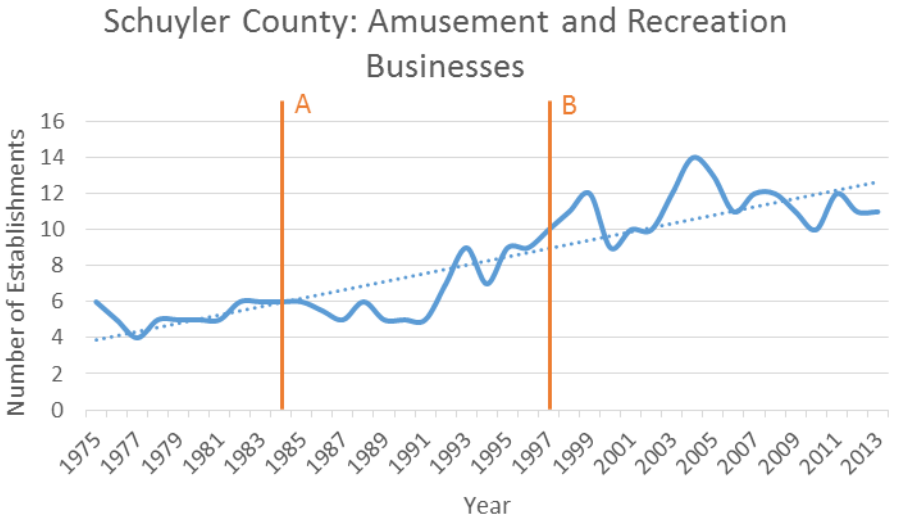
Lake natural gas storage facility are both underground storage facilities located entirely within Schuyler County.

We consider the Amusement and Recreation and the Accommodations Industries as being representative of the tourism and hospitality industry in Schuyler County. For each industry we look at the number of business establishments and number of employees. As shown in the following charts, there does not appear to be a meaningful correlation between the tourism industry and new industrial uses similar to the proposed Project.



A) Watkins Glen LPG storage terminal placed into service
B) Seneca Lake natural gas storage facility placed into service



A) Watkins Glen LPG storage terminal placed into service
B) Seneca Lake natural gas storage facility placed into service

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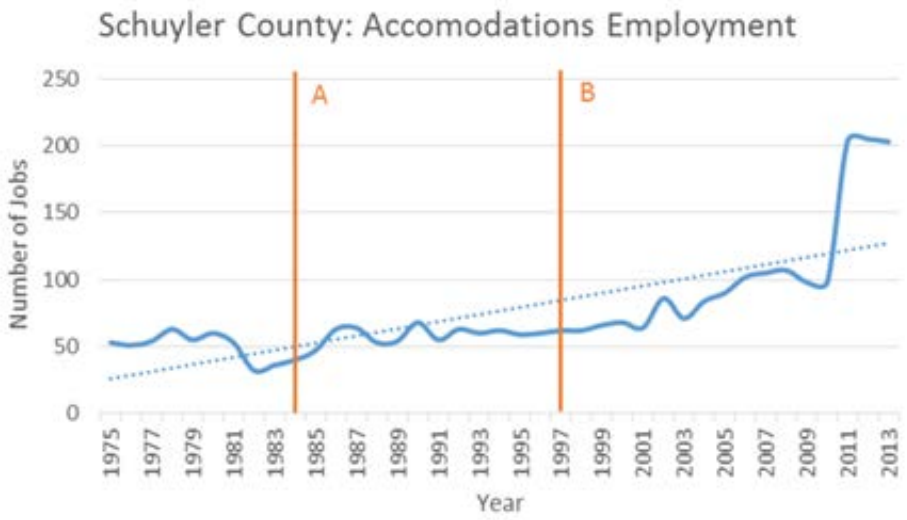
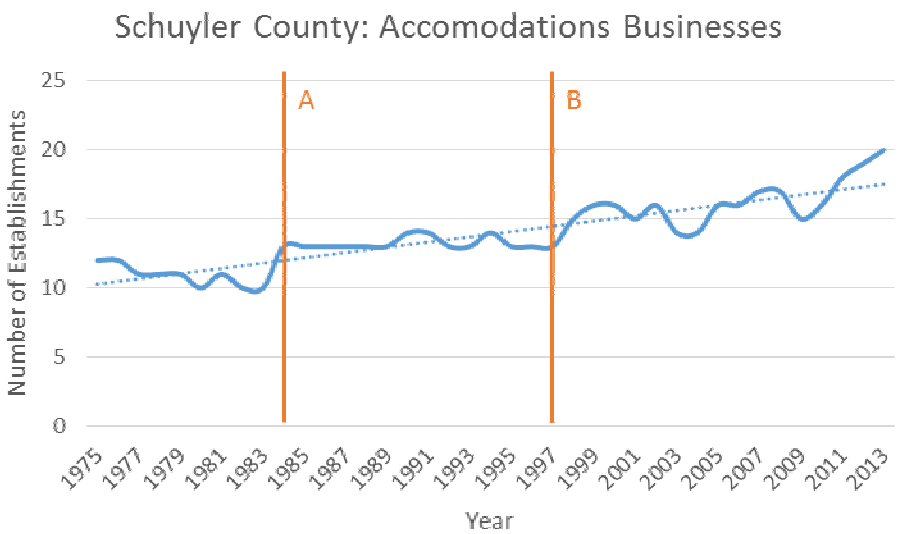


A) Watkins Glen LPG storage terminal placed into service
B) Seneca Lake natural gas storage facility placed into service



A) Watkins Glen LPG storage terminal placed into service
B) Seneca Lake natural gas storage facility placed into service

Conclusion: Impact on Tourism

Tourism has not appeared to be adversely impacted by the existing LPG and natural gas storage activities that have occurred or are occurring in and around the Project Site. Furthermore, as outlined previously in this analysis, there appear to be no visual, noise, traffic, smell, health or other adverse conditions related to the Project that might potentially impact tourism. We can find no basis to expect a meaningful impact on tourism. We note that propane is used in the winery industry for heating fuel, crop drying and other purposes. To the extent that local propane storage has helped lower costs in Schuyler County, the local wineries using propane have benefitted from the cost savings.

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Property Value Impacts

Literature Review

We conducted a literature review for any existing studies that examined property value impacts of LPG (or similar) storage facilities and we are unable to find any relevant studies. Numerous studies have been conducted of oil and gas facilities, but these have focused on production facilities rather than storage. Production facilities have characteristics that are substantially different from the Project (particularly: building sizes, massing, heights; associated noise, plumes, flaring, odors, lighting, pollution, etc.). Therefore, these studies do not provide results that are appropriate to transfer to the Project. We discuss three such studies, below, that were presented in comments submitted to NYSDEC to ostensibly provide evidence as to how the Project would negatively impact property values. As described, we find each study to be non-relevant to the Project.

- **P.C. Boxall, W.H. Chan, and M. L. McMillan, "The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Hedonic Analysis," Resource and Energy Economics 27 (3) (2005): 248-269, doi: 10.1016/j.reseneeco.2004.11.003**

This report is focused mainly on property value impacts from natural gas in Alberta, Canada. Specifically, the focus of this report is sour gas, a "natural gas that contains hydrogen sulphide, a colourless flammable compound that has an unpleasant smell similar to that emitted by rotten eggs and that is hazardous to humans and animals in relatively low concentrations." Sour gas is significantly more hazardous than LPG to the point where setbacks are required by the government in the sour gas study area. The data for the analysis was limited to "areas having significant sour gas activity near the City of Calgary." Furthermore and more importantly, this study examines production facilities specifically. There will be no production of natural gas or LPG at the Project. The Project Site will only be for storage of propane and butane. Any property value impacts discussed in this study are therefore non-transferrable to the Finger Lakes LPG Storage Project as the scale, type and specifics of the Project are significantly different from the Alberta facility.

- **M.T. Bond, V.L. Seiler, M. Seiler, "Residential Real Estate Prices: A Room with a View," Journal of Real Estate Research, 2002, 23:1/2; 129-137**

This study examined whether residential properties with a view of Lake Erie have significantly higher property values than those without a view of the Lake. Unsurprisingly, homes with a view of the lake carry a significant premium over those without a lake view. Having a view was found to add approximately $257,000 to the sale price of a home.

The results of this study have no relevance to the Finger Lakes LPG Storage Project. Bond et. al. considered only whether a home had a lake view or not. Of relevance to the Project is whether an incremental change in an existing viewshed will impact property values. The Bond et. al. study did not address property impacts occurring because of a change in an existing viewshed. The Finger Lakes Storage Project will not block the view of the lake from any existing residential property. In fact, the visual impact study described above showed no visual impact from lake front properties in the area.

- **K. Hudson, "What's a View Worth?" The Wall Street Journal, February 7, 2013.**

This article cites "academic studies and appraisers" that a pristine view, especially of a lake or ocean, can boost a home's property by 5% to 300% but notes that a more common range is 10% to 50%. This range, however, only considers properties that have a view versus those that do not. As discussed above, no properties in question will have an impeded viewshed as a result of the Project. Furthermore, no properties will have their view of the lake or any other view obstructed by the Finger Lakes LPG Storage Project. The results of this study have no relevance to the Finger Lakes LPG Storage Project.

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Adjacent Land Uses

The Project Site is in an area where there has been continuous industrial use for decades, and has and is being used for bulk storage of hydrocarbons (previously propane storage and currently natural gas storage). As such, the proposed Project's use of the Site is consistent with historical patterns of use and is consistent with the Town's land use patterns. Therefore, there does not appear to be a significant land use change to note. Furthermore, the broad local and statewide support for the project from businesses representing a significant portion of the regional employment base, ranging from manufacturing and tourism businesses (including vineyards, wineries and motels) to economic development organizations to state trade associations, suggests an expected economic benefit from the project.[10] As with the tourism section, we can find no reasonable basis to expect surrounding property values to diminish due to the nature and characteristics of the Project (visual, noise, traffic, etc.). No economic impact anticipated.

Conclusion

After examining the potential sources of economic impact, we find that most will not generate an actual economic or fiscal impact in Schuyler County. Impacts from sounds, smells, and visual impacts will either be non-existent or effectively mitigated. As most of the movement of product will be by underground pipeline or existing rail lines, transportation impacts will be negligible. Health impacts are also not anticipated from the Project while potential catastrophic events have been deemed to be negligible by the appropriate officials as confirmed by multiple expert analyses.

A review of historical industry data suggest that LPG and natural gas storage activities have had no negative impact on the tourism industry in Schuyler County. We also find no reason why the tourism industry would be adversely impacted by the Project in the future due to the above conclusions about a lack of other types of impacts (smells, sounds, traffic, visual, etc.). Property values are not expected to be affected by the Project because any potential impacts will be minor and/or mitigated and because the Project does not represent a significant change to the character of the area.

Our analysis did find several areas where an economic or fiscal impact is likely to be realized. Construction of the Project and annual operations will both provide new jobs, earnings, and sales in Schuyler County. On the fiscal side of things, new property tax revenue from the Project Site will be magnitudes higher than some minor municipal service cost increases that are expected.

The net economic impact to Schuyler County is expected to be positive, and the net fiscal impact to the Town of Reading, the school district, fire district and county will also be positive. The table below summarizes the economic and fiscal impacts of the Project.

[10] Organizations and businesses that have publicly expressed support for the project include the following examples: Associated Builders and Contractors – Empire State Chapter, Associated General Contractors of America – New York State Chapter, New York Farm Bureau, New York Propane Gas Association, Propane Gas Association of New England, New York Construction Materials Associations, Manufacturing Association of Central New York, The Council of Industry, Regional Economic Development Council of the Southern Tier, and Unshackle Upstate. Source: www.nypropaneadvocacy.com

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Summary of Economic and Fiscal Impacts	
Impact Category	Impact Finding
Economic Impacts (Schuyler County)	
Construction Impact	Construction will generate a one-time annual impact of 58 total jobs, $2.3 million in earnings, and $18 million in economic output (sales)
Operations Impact	Annual operations will generate 17 jobs, including 6 off-site jobs in Schuyler County. The project will also generate $684,000 in annual earnings and $507,000 in annual economic output (sales) in the County
Fiscal Impacts	
Property Tax Revenue	The Project will generate $617,000 in new property tax revenue annually. Schuyler County, the Town of Reading, the Reading Fire District, and the Watkins Glen Central School Distict will receive a share of that revenue.
Municipal Service Costs	Municipal costs generated as a result of the Project are estimated to be about $3,760 annually. The Schuyler County Sheriff's Office and the Watkins Glen Fire Department are the municipal service providers that will be affected by the Project

Overall, the Project will have a *one-time* economic impact to Schuyler County of 58 jobs, $2.3 million in earnings, and $5.6 million in economic output. Additionally it will generate an *annual* economic impact of 17 jobs, $684,000 in earnings, and $507,000 in indirect economic output in the County. The net fiscal impact of the project will be $613,000 annually.

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Appendix A: What is an Economic Impact Analysis?

The purpose of conducting an economic impact study is to ascertain the total cumulative changes in employment, earnings and output in a given economy due to some initial "change in final demand". To understand the meaning of "change in final demand", consider the installation of a new widget manufacturer in Anytown, USA. The widget manufacturer sells $1 million worth of its widgets per year exclusively to consumers in Canada. Therefore, the annual change in final demand in the United States is $1 million because dollars are flowing in from outside the United States and are therefore "new" dollars in the economy.

This change in final demand translates into the first round of buying and selling that occurs in an economy. For example, the widget manufacturer must buy its inputs of production (electricity, steel, etc.), must lease or purchase property and pay its workers. This first round is commonly referred to as the "Direct Effects" of the change in final demand and is the basis of additional rounds of buying and selling described below.

To continue this example, the widget manufacturer's vendors (the supplier of electricity and the supplier of steel) will enjoy additional output (i.e. sales) that will sustain their businesses and cause them to make additional purchases in the economy. The steel producer will need more pig iron and the electric company will purchase additional power from generation entities. In this second round, some of those additional purchases will be made in the US economy and some will "leak out". What remains will cause a third round (with leakage) and a fourth (and so on) in ever-diminishing rounds of spending. These sets of industry-to-industry purchases are referred to as the "Indirect Effects" of the change in final demand.

Finally, the widget manufacturer has employees who will naturally spend their wages. As with the Indirect Effects, the wages spent will either be for local goods and services or will "leak" out of the economy. The purchases of local goods and services will then stimulate other local economic activity; such effects are referred to as the "Induced Effects" of the change in final demand.

Therefore, the total economic impact resulting from the new widget manufacturer is the initial $1 million of new money (i.e. Direct Effects) flowing in the US economy, plus the Indirect Effects and the Induced Effects. The ratio between Direct Effects and Total Effects (the sum of Indirect and Induced Effects) is called the "multiplier effect" and is often reported as a dollar-of-impact per dollar-of-change. Therefore, a multiplier of 2.4 means that for every dollar ($1) of change in final demand, an additional $1.40 of indirect and induced economic activity occurs for a total of $2.40.

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Appendix B: Municipal Service Provider Letters

Oct 08 2014 1:39PM SCHUYLERCOUNTYO 6075358216 p.2

Office of the Sheriff
SHERIFF WILLIAM E. YESSMAN JR.
106 TENTH STREET, UNIT 2, WATKINS GLEN, NY 14891

UNDERSHERIFF
Breck A. Spaulding

LIEUTENANT
Michael A. Notarfonzo

PHONE (607) 535-8222 • FAX (607) 535-8216
EMERGENCY – DIAL 911

CRIMINAL INVESTIGATORS
Craig N. Gallow
Matthew J. Maloney

October 8, 2014

Dear Mr. N'dolo:

This letter is confirmation that you and I reviewed the potential impacts of the proposed Finger Lakes LPG Storage expansion project on the Schuyler County Sheriff's Office. It is my assertion that the bulleted points below accurately reflect the information I provided to you during our conversation on October 8th, 2014, as well as my impressions of what the potential impacts of the project will be on the Sheriff's Office.

SUMMARY:

- There may be increased costs to the Sheriff's Office due to a potential increase in protests at the project site.
- Existing protests have occurred at a rate of approximately three per 18 months (i.e. annual rate of 2 per year).
- The Sheriff's office has an expense of approximately $85 per day for an average of 10 days for each convicted female protestor ($850 total per convicted female protestor) because such females convicts have to be housed in non-County owned facilities.
- Four females have been arrested across three different protests.
- Overtime costs associated with each protest responded to totals approximately $1,000 per event. This is largely due to extra staff time needed to respond, transport arrested protestors for processing, and transport convicted female protestors to a non-local facility for boarding during their sentence.
- Aside from the costs associated with protests described above there are no other expense increases anticipated for the Sheriff's Office.

Respectfully Signed,

William E. Yessman, Jr.
Schuyler County Sheriff

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An Equal Opportunity / Affirmative Action Employer

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Schuyler County
Emergency Management
106 Tenth Street, Unit 36
Watkins Glen, New York 14891
607-535-8200

Coordinator
Bill Kennedy
bkennedy@co.schuyler.ny.us

StormReady

Deputy Coordinator
Brian Gardner
bgardner@co.schuyler.ny.us

Fire - EMS - 911 - EMO - Hazmat

October 24, 2014

Dear Mr. N'dolo:

This letter is confirmation that you and I reviewed the potential impacts of the proposed Finger Lakes LPG Storage Expansion Project on the Schuyler County Emergency Management Office. It is my assertion that the bulleted points below accurately reflect the information I provided to you during our conversation on October 10th, 2014, as well as my impressions of what the potential impacts of the project will be on the Emergency Management Office.

SUMMARY:

- The County's Emergency Management Office already has plans in place for LPG storage and transmission through pipeline. Railroad related planning efforts are currently underway for the entire county.
- To date, the County has not identified any specific equipment or operational/capital cost that would occur as a result of the expansion project. However, as planning continues, it is possible that new costs could be identified.
- Once the expansion project is complete, we do not anticipate any significant additional planning-related costs to the County.

Sincerely,

William Kennedy
Schuyler County
Emergency Management Coordinator

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Web: www.schuylercounty.us Facebook: www.facebook.com/schuyleremo Twitter: www.twitter.com/SchuylerEMO

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Watkins Glen Fire Department
Fire Chief Judson Smith
201 N Perry Street, Watkins Glen NY 14891
PH: 607-857-4544 Fax: 607-535-9315
Email: Judson.smith@watkinsglenfiredepartment.com

Dear Mr. N'dolo:

This letter is confirmation that you and I reviewed the potential impacts of the proposed Finger Lakes LPG Storage expansion project on the Watkins Glen Fire Department. It is my assertion that the bulleted points below accurately reflect the information I provided to you during our conversations on October 10th and 15th, 2014, as well as my impressions of what the potential impacts of the project will be on the Fire Department.

SUMMARY:

- The Fire Department occasionally responds to calls around the existing facility, but the facility personnel take care of any issues on the site itself. It is not anticipated that the frequency of these response would increase as a result of the expansion project.

- The Fire Department also serves as EMS first responders. There are no anticipated new costs for EMS services provided by the Fire Department as a result of the project.

- There may be increased costs to the fire department if any new or additional methanol is stored on site. Methanol fire events require a special type of foam (Class B) to suppress the fire and absorb the chemical. The fire department currently has one Class B Induction System with 25 gallons of Class B foam. This amount may be insufficient if any additional methanol is stored on site, in which case the Fire Department would purchase a second induction system with a capacity of 100 additional gallons of Class B foam. This new induction system would cost approximately $600 for the induction wand and $1500 for the foam.

- The expansion project would involve the delivery of LPG via rail car. Fire department personnel get training as recruits in propane firefighting. However, it can be hard to keep that training up to date for personnel who might be involved in a response to a train derailment. State facilities in Montour have the only LPG-type simulation equipment available in the area; however, it is very hard for the Fire Department to book that equipment for regular training exercises. Because of that difficulty, it would be helpful for the department to have its own flammable gas training simulator so that fire department personnel could use the simulator to train. The cost of a new flammable gas training simulator is estimated to be between $10,000 and $25,000.

- No other increases in expenses other than those described above are anticipated.

Sincerely,
Judson Smith
Fire Chief
Watkins Glen Fire Department

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Appendix C: Quest Confirmation Letter

QUEST
CONSULTANTS INC.®

January 29, 2015

Mr. Michael N'dolo
Camoin Associates, Inc.
120 West Avenue, Suite #303
Saratoga Springs, NY 12866

Dear Mr. N'dolo:

This letter is confirmation that I have reviewed the Information Presented in Table 1 and find the values presented there to be consistent with the preliminary findings of Quest's quantitative risk analysis (QRA) for the transportation aspects of the Finger Lakes LPG Storage Project in Schuyler County, New York.

The numbers shown in Table 1 are classified into two categories: reference values (those shown in italics) and calculated values. The reference values found in Table 1 are publicly available data (e.g., the number of miles of traveled by rail in Schuyler County), or are referenced in Quest's preliminary report to Crestwood, dated 29 October 2014 (Quest document number 6972-MSC02-RevD0). Full reference, explanation, and presentation of the reference values will be given in Quest's QRA report (Quest document number 6972_QRA01_RevD2).

You will notice that some of the values in the table have been changed, simply to correct for the current product flow assumptions. For example, the project-specific truck failure rates have not been included due to the forecast that no LPG truck movements will be associated with Finger Lakes LPG. Please let us know if you have any questions or concerns about the information presented in Table 1.

Sincerely,

Jeffrey D. Marx
Senior Engineer

MAILING: P.O. BOX 721387 NORMAN, OK 73070-8069
SHIPPING: 908 26TH AVENUE NW, SUITE 103 NORMAN, OK 73069
TELEPHONE: (405) 329-7475 FAX: (405) 329-7734
E-mail: info@questconsult.com

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Table 1
LPG Transportation Release Event Probabilities

Probability of Railcar Releases and Event Distribution	
Frequency of release per railcar-mile	*2.023E-08*
Frequency of a BLEVE per railcar-mile	*3.287E-10*
Fraction of releases that are BLEVEs (catastrophic)	0.0162
Fraction of releases that are 3-inch holes (major)	0.0411
Fraction of releases that are 1-inch holes (puncture)	0.0455
Fraction of releases that are 1/4-inch holes (leak)	0.8971
Probability of Crestwood Railcar Events	
Number of propane railcars per year	*105*
Number of butane railcars per year	*1,680*
Total number of railcars per year	1,785
Total number of miles traveled in Schuyler County by rail	*12*
Total number of railcar miles per year	21,420
Annual probability of any release (Crestwood railcars)	4.333E-04
Annual release chance of one in...	2,310
Annual probability of a railcar BLEVE (Crestwood railcars)	7.020E-06
Annual BLEVE chance of one in...	142,450
% of releases that are major or catastrophic	5.7%
Annual probability of a major/catastrophic release (Crestwood railcars)	2.440E-05
Annual major/catastrophic release chance of one in...	40,990
Probability of Pipeline Releases and Event Distribution	
Frequency of a pipeline release per mile per year	*1.570E-03*
Fraction of ruptures (catastrophic)	0.3669
Fraction of 3-inch holes (major)	0.2427
Fraction of 1-inch holes (puncture)	0.1713
Fraction of 1/4-inch holes (leak)	0.2503
Probability of Crestwood Pipeline Events	
Number of new pipeline miles	*0.5*
Annual probability of any release (new Crestwood pipeline)	7.850E-04
Annual release chance of one in	1,274
% of releases that are major or catastrophic	61%
Annual probability of a major/catastrophic release (Crestwood pipeline)	4.785E-04
Annual major/catastrophic release chance of one in...	2,090
Probability of Tank Truck Releases and Event Distribution	
Frequency of release per tank truck-mile	*5.839E-08*
Frequency of a BLEVE per tank truck-mile	*4.189E-09*
Fraction of BLEVEs per tank truck-mile (catastrophic)	0.0717
Fraction of 3-inch holes per tank truck-mile (major)	0.0388
Fraction of 1-inch holes per tank truck-mile (puncture)	0.0430
Fraction of 1/4-inch holes per tank truck-mile (leak)	0.8463

QUEST

NYSDEC OHMS Document No. 201166576-00030

Addendum: Revised Base Case

The economic and fiscal impact analysis of the Finger Lakes LPG Storage Project completed by Camoin Associates was based on the Company's current assumptions regarding the movement of product to and from the site. Specifically, the Company is expecting that product will moved to and from the site via pipeline and rail only. In previous materials submitted to the NYSDEC in 2012, the Company indicated that a portion of product would be moved to and from the site via tanker trucks, which reflected market conditions at the time.

In this addendum, we consider how the previously proposed mix of product movement methods that included new truck traffic to the area would impact the economic and fiscal impact analysis.

2012 Base Case Assumptions

The table below shows the Company's product movement expectations in 2012. In this base case, trucks would only transport product out of the facility. About 25% of butane and 75% of propane moved out of the facility would be by truck.

Product Movement (2012 Base Case)			
	Truck	Rail	Pipeline
Inbound			
Butane	0%	25%	75%
Propane	0%	10%	90%
Outbound			
Butane	25%	75%	0%
Propane	75%	10%	15%

Source: Finger Lakes LPG Storage, LLC

Based on the 345 barrel capacity of a tanker truck, it would be expected that there would be 3,261 propane-loaded trucks and 435 butane-loaded trucks out of the facility annually (a total of 3,696 loaded trucks out per year). Peak truck traffic time would be in the winter months (October 1 – March 31). It is expected that during the peak heating months the site would load 20-21 trucks per day on average. Truck loading would occur during a 12 hour period.

According to a traffic analysis conducted by GTS Consulting, approximately 60% of truck traffic generated by the site would travel to/from the north on Route 14 and 40% would travel to/from the south on Route 14. This averages out to about 12 trucks to/from the north an 8 trucks to/from the south each day during the peak season. During the non-peak season, traffic volumes would be much lower and in summer time there would be virtually no truck traffic. In a worse-case scenario where the site is operating at capacity, there would be a maximum of 30 trucks per day over a 16-hour window. This translates into an average of one truck per hour on average from each direction.

Potential Impacts from New Truck Traffic

In 2010 GTS Consulting analyzed the impact of traffic under the assumption of 30 trucks per days, above the 20.2 trucks per day (peak) that we consider in this addendum. The independent analysis concluded that even under this higher traffic volume scenario, "the additional traffic generated by the proposed Fingerlakes LPG Storage facility is negligible and will generally not be noticeable to existing motorists or residents in the area." The report also noted that there would be no adverse impacts from traffic congestions as a result of the new truck traffic.

We also refer to a letter submitted to NYSDEC by an official representing the State of New York Department of Transportation (NYSDOT) Region Six (please see Appendix to this Addendum for a copy of this letter). The letter concludes that "the traffic impacts associated with the proposed action do not

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represent a substantial increase to the existing traffic volumes, nor do they present a need for mitigation to the highway."

Therefore, due to the findings of the GTS analysis, the NYSDOT Region Six letter, and based on the low traffic volume, and seasonality of the truck traffic, we would not expect new truck traffic to be significant enough to decrease local property values or detract from the character of the community. We would also not expect any measurable health impacts associated with the modest amount of new truck traffic or increased road maintenance costs.

The seasonality of truck traffic is also an important consideration with respect to potential impacts to the tourism industry. Tourism in the area is primarily during the warm weather months. Therefore, peak truck traffic volumes would run countercyclical to tourism activity. No economic impact to the local tourism industry would be expected.

We also consider whether the sound associated with the new truck traffic would have an economic impact. The sound study completed by HUNT in 2011 and revised in 2013 measured truck activity sound levels at a similar facility. Based on that analysis, the sound impact from truck unloading activities "could cause an increase of 2dBA to the ambient sound level at Receptor #5 and no noticeable increase elsewhere. This increase at Receptor #5 would be unnoticeable to tolerable as stated by the NYSDEC." Therefore, we would not anticipate an economic impact from increased sounds associated with new truck traffic.

Catastrophic events related to the new truck traffic also have the potential to cause an economic impact. The table below shows the frequency of tank truck releases and event distribution, as provided by Quest. For an explanation of BLEVEs, please see main report body.

Probability of Tank Truck Releases and Event Distribution	
Frequency of release per tank truck-mile	5.839E-08
Frequency of a BLEVE per tank truck-mile	4.189E-09
Fraction of releases that are BLEVEs (catastrophic)	0.0717
Fraction of releases that are 3-inch holes (major)	0.0388
Fraction of releases that are 1-inch holes (puncture)	0.0430
Fraction of releases that are 1/4-inch holes (leak)	0.8463

Source: Quest Report, Interview w ith Quest, Camoin Associates

As shown in the table below, there are approximately 2,218 loaded northbound trucks and 1,478 loaded southbound trucks each year. Based on the number of miles that these trucks would travel in Schuyler County, we estimate about 33,000 loaded truck miles per year in the County. Based on the probability and event distribution table above, we anticipate an annual major or catastrophic release chance of one in 4,659. We consider this to be a near zero probability event and do not expect an economic impact to result from events related to tank truck releases.

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Probability of Tank Truck Events (Schuyler County)	
Northbound Loaded Trucks per Year	2,218
# of Northbound Miles in Schuyler County	3
Northbound Loaded Truck Miles per Year in Schuyler County	6,653
Southbound Loaded Trucks per Year	1,478
# of Southbound Miles in Schuyler County	18
Southbound Loaded Truck Miles per Year in Schuyler County	26,611
Total Loaded Truck Miles per Year in Schuyler County	33,264
Annual probability of any release in Schuyler County	1.94E-03
Annual release chance of one in…	515
% of releases that are major or catastrophic	11%
Annual probability of a major/catastrophic release	2.15E-04
Annual major/catastrophic release chance of one in…	4,659

Source: Quest Report, Interview with Quest, Camoin Associates

Conclusion

Under the 2012 Base Case we do not expect the findings of the economic and fiscal impact analysis to change. The volume of the new truck traffic in this scenario is not significant enough to impose a measurable impact. Furthermore, peak truck traffic would occur during off-peak tourism months limiting the potential impact to the local tourism industry.

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Addendum Appendix: NYSDOT Letter to NYS DEC

State of New York
Department of Transportation
Region Six
107 Broadway
Hornell, New York 14843
www.dot.ny.gov

RECEIVED
JAN 11 2012
NYSDOT REGION 6
TRAFFIC SAFETY & MOBILITY

BRIAN C. KELLY, P.E.
ACTING REGIONAL DIRECTOR

JOAN McDONALD
COMMISSIONER

January 11, 2012

Mr. David L. Bimber
Deputy Regional Permit Administrator
NYS DEC, Division of Environmental Permits
6274 East Avon-Lima Road
Avon, New York 14414-9519

RE: Fingerlakes LPG Facility

Dear Mr. Bimber:

We have reviewed the traffic information from the original submission received, as well as separate submissions from GTS Consulting, and have concluded that the traffic impacts associated with the proposed action do not represent a substantial increase to the existing traffic volumes, nor do they present a need for mitigation to the highway.

Because the development requires access to the State Highway system, a Highway Work Permit (HWP) will be required. Under the Department's HWP process, a detailed review of the point of access to the state highway will be conducted and appropriate geometric elements will need to be constructed.

As a permitting agency, the New York State Department of Transportation shall be considered an Involved Agency under the SEQRA.

We appreciate your keeping us apprised of this matter.

Sincerely,

Andrew H. Williams, P.E.
Acting RPPM, Region 6
AHW:WFP:lf

cc: T. Alimossy, Resident Engineer Residency 6-3
P. McAnany, Acting Regional Traffic Engineer

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Camoin Associates, Inc.
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Saratoga Springs, NY 12866

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camoin associates
ECONOMIC DEVELOPMENT

NYSDEC OHMS Document No. 201166576-00030

HUNT

ENGINEERS, ARCHITECTS & LAND SURVEYORS, P.C.
4 Commercial Street + Suite 300
Rochester, New York 14614
585 327-7950 TEL
585 327-7949 FAX

Memorandum

Date:	**February 9, 2015**
To:	**Kevin Bernstein; Bond, Schoeneck & King**
From:	Paul Congdon, HUNT
Copy:	
Project:	Finger Lakes LPG Storage
Re:	Sandstone Environmental Noise Review

In the Finger Lakes LPG Storage Project, Finger Lakes LPG Storage, LLC retained the services of HUNT Engineers, Architects & Land Surveyors (HUNT) to perform a noise analysis to meet the requirements of the New York State Department of Environmental Conservation (NYSDEC) policy. In January of 2015, Sandstone Environmental Associates, Inc. (Sandstone) performed a noise review of the proposed project and above mentioned report. In the Sandstone report, they identified several deficiencies within the HUNT report. This memo was prepared to address these deficiencies.

The Sandstone report recommends that the region of influence should be enlarged to include geographic areas which would be affected by transportation traffic to and from the site. This includes areas along New York State Route 14 as well as the eastern shore of Seneca Lake. As noted in the report, truck and rail traffic is currently part of the noise landscape in their recommended region of influence. Based on published traffic data from the NYSDOT, the traffic count along NYS Route 14, adjacent to the project site, is 7811 vehicles per day. Of these vehicles, 494 are trucks (3 or greater axles). Assuming the worst case scenario of 30 truck loads per day, this could increase the traffic count by 60 trucks[1]. These trucks will be operating during the specified operating hours and therefore is not likely to result in a noise that would be out of character along the route 14 corridor which is a NYS truck route.

The proposed region of influence is also based on rail traffic, which is another sound source currently found in the area surrounding the project site. The original plan (and this has not changed under the current market outlook) could result, at most 7 additional rail cars per day, which could require an additional rail trip per day if the railroad company does not have a previously scheduled trip. These potential rail and truck traffic increases are based on the original plan and do not include the revised transportation allocation. With this in mind, the potential traffic increases would not be out of character in the proposed region of influence so it is not necessary to expand the study area because of this, or include these noise sources in the analysis.

The on-site activities, which have the potential to be most out of character with existing noise, are located approximately 4000 feet from the western lake shore. This would result in an approximately 38 dB(A) reduction in any on-site sound levels, excluding any reductions due to topography and vegetation. Neglecting any reductions over the water, the maximum on-site noise level of 88.9 dB(A) (train activities) would be perceived on the eastern shore as 51.9. Although this level is higher than the baseline level observed by Sandstone, this is less than the currently observed sound peaks at the receptor, including industrial noise. Once any environmental characteristics are taken into account, the sound is likely to be imperceptible.

It should also be noted that the Sandstone baseline measurements were taken in the middle of winter when ambient sound levels are at their lowest. The NYSDEC Noise Policy states “Summer time noises have the greatest potential for causing annoyance because of open windows, outside activities, etc. During the winter people tend to spend more time indoors and have the windows closed. In general, building walls and windows that are closed provide a 15 dB reduction in noise levels.” Therefore, there is not likely to be adverse impacts on the eastern shore, from onsite activities, and it was not necessary to include it in the study.

[1] I now understand that at the current time, because of changes in market conditions and the availability of the Enterprise TE Products Pipeline, Finger Lakes does not currently expect there to be any truck traffic from its terminal.

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The Sandstone report also goes on to identify that the measurements of proposed on-site activities, including rail and truck traffic, have not been properly monitored. Sound levels were recorded throughout the duration of the activity including various levels of activity and idle time which would be consistent with the proposed project site. Even if the observation of the incorrect train Leq, by Sandstone, is valid, the appropriate adjustment would raise the expected average sound levels by only 1.9 dB(A) at nearby receptors. Such an adjustment to the expected sound levels would be as follows:

Receptor	Revised Train Leq	Ambient Leq
#1	58.0 dB(A)	58.1 dB(A)
#2	60.0 dB(A)	54.0 dB(A)
#3	55.5 dB(A)	60.4 dB(A)
#4	57.0 dB(A)	58.0 dB(A)
#5	58.0 dB(A)	54.5 dB(A)

Even with these revised calculations, the only receptor which would see potentially adverse increases is Receptor #3 where there could be an increase of 6 dB(A) during train unloading activities. As this location is the property line adjacent to a truck repair shop, it would not be considered a sensitive receptor and no adverse impacts could be expected.

The measurements of the train at 800 ft were the equivalent sound levels for two time periods; without train activities and with train activities, and is not a direct measurement of the train sound level. The equivalent time period when the train was operating was less than 1 dB(A) over the ambient sound level, which shows that the train would be unnoticeable at this distance.

At the project site, the ambient noise levels were measured using Equivalent Noise levels. As stated in the NYSDEC noise policy "The Leq value provides an indication of the effects of sound on people. It is also useful in establishing the ambient sound levels at a potential noise source." The Leq noise levels were used in this analysis based on comments from the NYSDEC and monitoring was performed for the time periods recommended by the NYSDEC. The measurement locations were either at the property line or at the receptor, as recommend in the NYSDEC noise policy, facing the noise sources to get an accurate assessment potential impacts. The exception to this was the hotel receptor which was adjusted in a previous memo prepared by HUNT.

The proposed sound levels were analyzed at the receptors using the NYSDEC first order analysis method, which does not account for vegetation or topography, which in this instance would reduce the potential sound levels beyond the calculated levels. The analysis also neglects any effects due to wind or atmospheric conditions, which although they can have a significant impact on noise levels, are generally temporary in nature and should be excluded, as recommended by the NYSDEC noise policy. Based upon the results of this analysis, it was determined that the proposed mitigation methods were not required to be analyzed.

The Sandstone report identifies that the proposed construction noise has not been evaluated by the report. The construction activities have been outlined in the Stormwater Pollution Prevention Plan along with a detailed schedule. The construction of the improvements on the project site is typical of activities which occur throughout the construction season. There are no receptors requiring quiet conditions, such as a school or church near the project site. Because this noise is not out of character and is temporary in nature, it was assumed that there would be no adverse impacts and the construction noise was not necessary to be analyzed.

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STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Application of Finger Lakes LPG Storage, LLC to construct an underground liquefied natural gas storage facility with pipeline connection and rail and truck load/unload racks in the Town of Reading, Schuyler County	**DEC Application No. 8-4432-00085**

AFFIDAVIT OF WILLIAM KENNEDY

1. My name is William Kennedy. I am employed by Schuyler County, New York, and my current position is Coordinator, Schuyler County Emergency Management. I have been employed in my current position since 2003 and, I have worked in the field of the emergency services for more than 37 years.

2. In my current position, I am responsible for the services provided by Schuyler County's Emergency Management Office, which oversees, assists and coordinates the fire service, emergency medical service, hazardous material response, and 911 service throughout Schuyler County. The Emergency Management Office coordinates disaster preparedness activities and disaster responses.

3. Liquefied petroleum gas ("LPG") and natural gas have long been stored in and transported through Schuyler County. LPG is transported through Schuyler County by pipeline, rail and truck. LPG has been stored underground at a mined storage facility (with pipeline connectivity and truck unloading racks) located within the Town of Reading since approximately 1984, and LPG was stored underground in salt caverns located within the Town of Reading for a period of 20 years (1964-1984). Natural gas is transported in Schuyler County by at least five

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pipeline operators (excluding natural gas gathering lines and local distribution lines), and natural gas is stored underground in a salt cavern storage facility (with pipeline connectivity) located within the Town of Reading. A more detailed description of the scope of the LPG and natural gas transportation and storage activities occurring within Schuyler County is described in more detail in the draft "Appendix to the Hazardous Materials Plan – Transportation of Liquefied Petroleum Gas LPG" ("Draft Appendix") attached to the petition for amicus status submitted by Schuyler County Legislators Harp and Lausell to ALJ McClymonds in advance of the issues conference for the proposed Finger Lakes LPG Storage Project.

4. In my professional opinion, the Schuyler County government has adequately anticipated and addressed the risks of various activities throughout Schuyler County, including risks associated with the storage and transportation of LPG. For example, these particular risks identified, analyzed and addressed by Schuyler County over several years, culminating with completion and implementation of the Schuyler County Hazard Mitigation Plan (May 2008) ("Hazard Mitigation Plan"). A multijurisdictional plan approved by the Federal Emergency Management Agency, the Hazard Mitigation Plan ranks (a) Hazardous Material Released in Transit, which would include the release of LPG as a result of a derailment or truck accident, as a Moderately High Priority Hazard, and (b) Hazardous Material Released from a Fixed Site, which would include the release of LPG from a pipeline or storage facility, as a Low Priority Hazard. Other Moderately High Priority Hazards ranking higher than Hazardous Material Released in Transit include severe storms, ice storms and terrorism, whereas only blight is ranked below Hazardous Material Released from a Fixed Site.

5. With respect to uncontrolled release of material during transport, the Hazard Mitigation Plan characterizes the probability of such an event as a "Regular Event (occurs once

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every one to seven years)." With respect to uncontrolled release of material from a stationary facility, the plan characterizes the probability of such an event as a "Rare Event (occurs less than once every 50 years)." The plan indicates the last uncontrolled release during transit occurred in December 2003, and that no uncontrolled releases from stationary facilities had been recorded that exceed "routine" spills. In each instance, the plan indicates that "serious injury or death is likely, to large numbers" are anticipated outcomes of uncontrolled releases.

6. Schuyler County is in the process of updating the Schuyler County Hazard Mitigation Plan that was approved in May 2008. As part of the process a Hazard analysis was again conducted June 18, 2014 using New York State's automated interactive program HAZNY. As in 2008 a group was assembled to conduct this hazard analysis and was facilitated by New York State Office of Emergency Management. The group included representation from the Schuyler County Local Emergency Planning Committee, Schuyler County Legislature, Public Health, Sheriff's Office, and the Emergency Management/Fire Coordinators Office. Several local and State planning partners participated in this process to included, Schuyler Hospital, American Red Cross, Town of Hector, Department of Transportation, Department of Environmental Conservation, Office of Emergency Management, Department of Labor, and the NY State Police. The program asks specific questions regarding potential hazards in the community and records and evaluates the response to those questions. HAZNY utilizes historical and expert data on selected hazards. HAZNY rated each hazard based on the group's assessment. During this process, Hazardous Materials Release in Transit was rated at a Moderately Low Hazard level as opposed to Moderately High Hazard level during the 2008 HAZNY. The update to the Hazard Mitigation Plan will reflect this new assessment.

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7. With respect to the risk of uncontrolled releases of LPG in transit or from stationary facilities since the Hazard Mitigation Plan was implemented, it is my professional opinion that the personnel (fire services, emergency medical or otherwise) responsible for responding to the disasters and other incidents contemplated by the Hazard Mitigation Plan are adequately trained for such events. Moreover, to the extent risks associated with certain activity (such as uncontrolled releases of LPG from derailments) increase within Schuyler County from time to time, it is my expectation that additional training related to the increased risks would be arranged for the fire service, emergency medical service, hazardous material response, and 911 service, as appropriate.

8. In my professional opinion, the substance of the Draft Appendix (including the release modeling included therein) is more than adequate to coordinate preparedness activities and responses for incidents involving uncontrolled releases of LPG in transit or from stationary facilities.

I declare under penalty of perjury that the above is true and correct to the best of my knowledge.

Dated: February 6, 2015

William Kennedy

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Norfolk Southern Letters

NYSDEC OHMS Document No. 201166576-00030

Michael R. Fesen
Norfolk Southern Corporation
Government Relations Manager

October 30, 2014

The Honorable Andrew M. Cuomo
Governor of New York State
NYS State Capitol Building
Albany, NY 12224

Dear Governor Cuomo:

Norfolk Southern is one the largest and most experienced common carrier railroads in the United States. Our companies have operated in New York since 1999 and more than 300 of our employees are based in New York. As an organization focused on the safety of our employees, communities and environment, we support the proposed Finger Lakes LPG storage project in Schuyler County, New York.

Opponents of the storage project claim that the transportation of liquefied petroleum gas (LPG) by rail presents unmanageable or extraordinary risks to local communities. We disagree. Our rail systems have transported freight, including hazardous materials like LPG, without incident throughout the Finger Lakes for decades. Our customers throughout upstate New York rely upon us to transport their fuels and products safely and reliably.

Exceptional Track Record

Class I railroads like us are required by federal law to offer to transport hazardous materials. Rail is an extremely safe way to transport hazardous materials: in fact, according to the Association of American Railroads, 99.9977% of all hazardous material rail shipments reach their destination without a release caused by a train accident. Our company transported 531,582 carloads of hazardous materials last year (compared to roughly 350,000 carloads five years ago), while experiencing only three accidental releases involving six tank cars and non-accident releases involving 63 railcars. None of these releases involved LPG or occurred within New York, and the amount released in each case was relatively small. Although we strive for incident-free operations, our performance record demonstrates that the transportation of hazardous materials by rail does not itself pose unacceptable risks to our communities.

According to the Federal Railroad Administration, 1,782 railcars carrying hazardous materials were transported in New York between January 1, 2004 and December 31, 2013, with only 7 hazardous material releases from 12 railcars. During the same period, only three reportable rail accidents or incidents occurred within Schuyler County (includes railcars carrying hazardous materials and non-regulated freight), none of which resulted in a fatality or a release of hazardous materials. Our local track record is particularly relevant considering (a) rail is the transportation lifeblood for many local, regional and national businesses located in New York, and (b) recent market changes are driving increased rail shipments of energy products in general and, in the case of the Northeast, greater volumes of propane are forecast to be transported to the Northeast to help satisfy winter demand.

We understand that opponents of the LPG storage project have expressed concern about the risks of a rail incident on the Watkins Glen Gorge Bridge, which spans a portion of the Watkins Glen State Park. Built in 1935, we have operated over the bridge without incident since 1999. Its 303 feet of track is inspected at least twice a week and its structure is inspected annually, and we adhere to stringent speed and weight restrictions while operating over it. We are confident in our ability to traverse the Watkins Glen Gorge Bridge without incident, as it is one of one more than 100 major railroad bridge structures that must be maintained and crossed to transport freight between Watkins Glen and Buffalo, New York. In fact, with more than 10,000 bridges across our system, we have experienced only three bridge failure incidences in the past decade.

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Significant Regulatory Oversight

Our strong operating record should not come as a surprise considering that railroads and the transportation of hazardous materials are heavily regulated. The Surface Transportation Board has broad economic regulatory oversight of freight railroads, including service and construction requirements, and the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) regulates the transportation of hazardous materials. PHMSA regulations are designed to achieve three goals: (i) ensure that hazardous materials are packaged and handled safely and securely during transportation; (ii) provide effective communication to transportation workers and emergency responders of the hazards of the materials being transported; and (iii) minimize the consequences of an incident should one occur. PMHSA pursues these goals by establishing rules for classification, packaging, hazard communication, incident reporting, handling and transportation of hazardous materials. In our case, PHMSA regulations require us to ensure our employees are appropriately trained to handle hazardous materials.

Moreover, the tank cars used to transport LPG are built to specifications and standards established by the U.S. Department of Transportation and/or Association of American Railroads. These enhanced specifications and standards address tank car design, type and thickness of material required to be used in construction, types of fittings, welding procedures, inspection, maintenance, repair, and quality assurance system requirements. For example, tank cars are equipped with safety devices and systems to protect the tank and fittings from damage during an accident or severe impact, such as pressure relief devices, tank head puncture-resistance systems, fire protection systems, service equipment (filling, discharge, venting, safety, heating, and measuring devices), and protection systems. It's fair to say tank cars are safer than ever.

Emergency Preparedness

We have more than 300 employees who have been specially trained and certified through the Hazardous Waste Operations and Emergency Response program developed by OSHA. Each employee who directly affects hazardous materials, including train crews, receives annual training in awareness, safety and security. We also actively participate in the Transportation Community Awareness and Emergency Response program known as TRANSCAER, and last year our employees conducted through TRANSCAER 256 rail-accident response training classes in 110 locations in 17 states (including 12 training courses in New York with 226 attendees in the last two year).

* * *

More importantly, this additional storage capacity will help ensure more propane for New York State. As we all know, last year the Empire State experienced one if its harshest winters ever.

We take great pride in our safety and environmental compliance and emergency preparedness, and our operating performance shows that hazardous materials can be transported safely by rail through upstate New York communities. We urge you to create jobs, grow tax base and broaden local economies by supporting the Finger Lakes LPG storage project.

Sincerely,

Michael R. Fesen
Government Relations Manager

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NORFOLK SOUTHERN

Norfolk Southern Corporation
Merchandise Marketing Department
110 Franklin Road, S.E.
Roanoke, Virginia 24042-0041

RECEIVED
OCT 11 2011
DEP-REGION 8

October 5, 2011

David L. Bimber
Deputy Regional Permit Administrator
NYSDEC
6274 East Avon-Lima Road
Avon, NY
14414-9516

Subject DEC Facility ID 8-4432-00085

Dear Mr. Bimber,

Representatives from Norfolk Southern attended the NY DEC hearing regarding the above cited matter but due to time constraints were unable to speak at the meeting.

We address the following issues:

NS Safety record

For the last 22 years Norfolk Southern has been the safest Class I railroad in the United State and has received the coveted Harriman Safety Award for doing so. We have handled propane and butane deliveries safely, to facilities in nearby facilities at Bath and Owego, NY, close to the Finger Lakes for many years.

Service to the facility

Rail service will be provided to the Inergy facility up to 24 loaded cars per day 5 days per week. We currently, as mentioned, serve other propane and butane storage facilities in the area.

The Railroad bridge

Find enclosed a letter from our attorney Karin Stamy to Kevin Bernstein regarding the safety of operating across this trestle.

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NORFOLK SOUTHERN

Noise

It is anticipated that the switching operation of the propane and butane cars will produce no noise beyond that normally found in rail operations.

In conclusion, Norfolk Southern supports the application of the Inergy project and urges its approval. If you have any questions please let us know.

Michael Fesen (PCW)

Michael Fesen
Manager
Government Relations Department
Norfolk Southern Railway
322 Third Street,
Elizabeth, NJ 07206
Phone 1 (717) 319-6870
Fax 1 (404) 653-3733
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Attachment

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Norfolk Southern Corporation
Law Department
Three Commercial Place
Norfolk, Virginia 23510-9241

Karin L. Stamy
General Attorney

Writer's Direct Dial Number

(757) 629-2864
(757) 823-5825 (fax)
karin.stamy@nscorp.com

February 23, 2011

Kevin Bernstein, Esq.
Bond Schoeneck & King
One Lincoln Center
Syracuse, New York 13202

Re: **Inergy Project**

Dear Kevin:

You have asked that Norfolk Southern Railway Company provide certain information about our freight rail bridge that crosses the Watkins Glen Gorge, specifically with regard to future rail transportation of liquefied petroleum gas ("LPG") that may be associated with the proposed Inergy facility.

As you are aware, freight bridge safety is regulated by the exclusive jurisdiction of the Federal Railroad Administration ("FRA"). FRA's regulations impose certain safety and inspection requirements on all rail bridges, including the Watkins Glen Gorge Bridge ("Bridge"). Pursuant to those requirements, the Bridge is regularly inspected. Those inspections confirm that the Bridge does not have any structural concerns, nor does it have any freight traffic restrictions.

Moreover, the Bridge's load carrying capacity is sufficient to handle current and expected future rail traffic. You have asked me what the weight of a loaded LPG rail car is. The allowable weight of a loaded LPG rail car is 286,000 pounds gross weight. This is within the load carrying capacity of the Bridge.

As you are also aware, the transportation of hazardous materials by rail, such as LPG, is closely regulated by the federal Department of Transportation ("DOT"). Loading and packaging requirements, which apply to shippers, are specified by DOT. Additional DOT regulations apply to the movement of hazardous materials by rail. NS is subject to those requirements.

You have asked about the safety history of the Bridge. NS has operated over the Bridge since June 1, 1999. We have had no environmental releases or incidents associated with the Bridge during our period of operation and are aware of none occurring before then. As you may

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be aware, NS is the industry leader in safety for all Class 1 railroads and has been the recipient of the E.H. Harriman Memorial Gold Medal award for the last 21 years.

Last, please be advised that NS is a common carrier that is required by federal law to provide transportation service upon reasonable request for any of the more than 1,200 commodities listed in the Standard Transportation Commodity Codes (STCC).

Very truly yours,

Karin Stamy

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C.T. MALE ASSOCIATES
Engineering, Surveying, Architecture & Landscape Architecture, D.P.C.

MEMORANDUM

TO: Kevin Bernstein, Esq.

FROM: Raymond Liuzzo, P.L.S.

RE: *Finger Lakes LPG Storage LLC*
Responses to Gas Free Seneca Petition
CTMA Project No.: 08.8696

DATE: February 9, 2015

Mr. Bernstein,

This memo contains responses to purported issues raised regarding the Visual Impact Analysis Report prepared by C.T. Male Associates dated November 20, 2014 in a Petition for Party Status submitted by Gas Free Seneca.

The Flad report in the Petition states the direct view from Hector Falls is not addressed in the visual analysis and it is the author's opinion that the project will have a significant adverse visual impact of the view from Hector Falls.

The bridge carrying New York State Route 414 over Hector Falls Creek is approximately mid-way between Camera Point 2 and Camera Point 3 as shown on the Visual Analysis Plan and Profile map. This bridge is nearby to the falls and represents the most likely view of the Project from the East side of Seneca Lake. A gap in vegetation exists west of the bridge which would provide a clear view towards the Project. As stated in the Visual Analysis, only the grass surface of the berm would be visible from Camera Points 2 and 3; the same holds true for the view from the falls. Also, as stated in the Visual Analysis, the embankments will be seeded with a native seed mix and allowed to germinate with herbaceous species that will further act to "blend" the brine pond embankments into the characteristic natural landscape on the western side of Seneca Lake.

The Petition also suggests that the gas flare is not well explained. The flare stack, smaller in height than a standard telephone pole, would be very difficult to see from any point on the east side of Seneca Lake with the unaided eye. The flare stack consists of a 25-foot tall pipe, grey in color being approximately 13" in diameter. The distance from the flare stack to the east shore of the lake is approximately 1.6 miles. At that distance, the stack would unlikely be visible without magnification. During normal operation the gas flare does not produce a visible flame. The gas flare only operates if there is an operational safety issue as a secondary safety measure. The gas flare will produce intermittent small flames once every 10 years during maintenance cycles of cavern sonar surveys and casing inspections per conditions of the draft DEC permit. Additionally, a shield will be installed around the flare so that the pilot flame is not visible from the any part of Seneca Lake or its shores. There are no adverse affects created because the flare stack is not in continuous use and the pilot flame is not visible.