Vibra-Tech

Proposed Tyoga Container Facility
Vibration Impact Study
West Water Street
Village of Painted Post
Steuben County, New York

Prepared for:

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2 Executive summary

This vibration impact study has been conducted to analyze the vibration impacts of the proposed 600,000-square foot Tyoga Container Warehouse Facility at 450 West Water Street on the adjacent properties, and the vibration impact of semi-trucks passing the properties located along the West Water Street access road.

This vibration impact study has been conducted based on guidelines provided by the Federal Transportation Administration (FTA), The Federal Highway Administration (FHWA), and existing ground vibration measurements recorded along West Water Street.

The following conclusions are made from this report:

1. The proposed warehouse facility will replace the former Ingersoll-Rand Foundry Site. No manufacturing operations will occur at the site. Semi-truck traffic traveling along West Water Street access road is the only anticipated source of vibration activity.

2. The closest warehouse loading dock will be approximately 200 feet from the nearest residence at 324 West Water Street. The predicted vibration at this residence induced by loading dock operations is below building damage and occupant impact vibration criteria recommended by the FTA. Vibration levels for residences at greater distances from the loading docks will also meet these vibration criteria.

3. Vibra-Tech Engineers (VTE) performed 24 hours of continuous ground vibration monitoring at three locations along West Water Street from Thursday, August 13, 2020 at 12:00 PM, through Friday, August 14, 2020 at 12:00 PM. No semi-truck traffic was observed on West Water Street during this period, only passenger vehicles and two-axle work trucks. Existing vibration levels resulting from traffic induced vibration are below vibration damage and occupant impact criteria recommended by the FTA.

4. VTE performed the measurement of ground vibration at 10 standoff distances from West Water Street during 14 passes of a loaded tractor-trailer. The tractor-trailer had a GVW of approximately 25,000lbs, with a load of approximately 17,000lbs. The truck traveled at about 20 mph during the testing. Based on these measurements the rate of ground vibration attenuation with distance from passing tractor and trailers was determined.

5. The proposed warehouse facility will create approximately 100 additional semi-truck passes along the West Water Street Access Road per day. The FTA vibration impact criteria

for occupants of residential structures is most restrictive when then number of events exceeds 70 per day.

6. Based on our measurements of loaded truck passes, ground-borne vibration levels inside four of the West Water Street residential structures induced by the passing trucks are predicted to be at the borderline of the FTA vibration impact criteria. Vibration levels are predicted to fall in the FTA designated "barely perceptible range." These residential structures are 54 feet or less from the roadway.

7. When the number of truck passes is reduced to 70 per day or less, ground-borne vibration levels inside all West Water Street residential and commercial structures induced by the passing trucks are predicted to meet the FTA vibration impact criteria.

8. Based on our measurements of loaded truck passings, ground-borne vibration levels induced by the passing trucks at all West Water Street structures are predicted to be significantly below the most stringent damage criteria for fragile and historic structures recommended by various government and academic organizations, regardless of the number of passes.

3 Introduction

This vibration impact study has been conducted to analyze the vibration impacts of the proposed 600,000-square foot Tyoga Container Warehouse Facility at 450 West Water Street on the adjacent properties, and the vibration impact of semi-trucks passing the properties located along the West Water Street access road. The proposed warehouse facility will create approximately 100 additional semi-truck passes along the West Water Street Access Road per day.

This vibration impact study has been conducted based on:

- Vibration impact guidelines provided by the Federal Transportation Administration and the Federal Highway Administration.
- Field measurements of existing West Water Street ground vibration levels conducted by Vibra-Tech Engineers August 2020.
- Tyoga Container Facility Site Plans and Civil Drawings, May 2020, Larsen Design Group.
- Tyoga Container Facility Transportation Impact Study June 2020, Larsen Design Group.
- Tyoga Container Facility Geotechnical Engineering Report July 2020, Haley & Aldrich.

4 Objectives

VTE was retained by Tyoga Container Facility to perform this Vibration Impact Study.

The following scope of work is provided for this project:

- Review site plans, geotechnical report, and Transportation Impact Study.
- Predict vibration levels from warehouse operations and semi-truck traffic at various structures along West Water Street.
- Measure vibration levels from a loaded semi-truck along West Water Street.
- Compare measured and predicted vibration levels to building damage criteria and occupant impact criteria.
- Preparation of final vibration impact analysis report.

5 Vibration Terminology

Vibration levels are quantified by a variety of parameters and metrics. To aid the reader, this section introduces general concepts and terminology related to environmental vibration. The following related technical terms are summarized and outlined below:

5.1 Vibration

Vibration is oscillatory motion that can be described in terms of, displacement, velocity, or acceleration. Because the motion is oscillatory, there is no net movement of the vibrating element and the average motion is zero. There are two ways in which traffic can induce vibration in nearby buildings, via ground-borne and air-borne paths.

5.2 Ground-Borne Vibration

Ground-borne vibration is caused by interaction of vehicle tires with pavement. Tire impact loads on the pavement are converted to stress waves which travel through the pavement and geology into the building foundation and vibrate the structure.

5.3 Air-Borne Vibration

Air-borne vibration is caused by low frequency sound produced by engines and exhaust which travel through the air and excite the building above the ground. Light flexible elements of the structure, such as windowpanes and door panels.

5.4 Frequency (Hz)

The number of times an element oscillates back in forth in one second is called its frequency. Vibration frequency is quantified in cycles per second, or Hertz (abbreviated Hz).

5.5 Peak Particle Velocity

The maximum instantaneous speed of a particle subjected to oscillatory motions. PPV is proportional to the stresses experienced within the system. Because of this proportionality, PPV is used as a metric in evaluating potential for building damage resulting from vibration. In general, vibration induced by transit systems is well below PPV levels necessary to cause structural or cosmetic damages in buildings. PPV is not generally used in addressing human impact to vibration.

5.6 Root Mean Square (rms) Velocity

Because the net average motion of a vibrating element is zero, the square root of the average of the squared velocity of the signal is used. The average is typically calculated over a one second period. The rms velocity is always less than the PPV. The rms velocity is used to convey the magnitude of vibration felt by the human body and is used as a metric for addressing human impact to vibration. The units are inches per second (in/sec).

5.7 Decibel Vibration Velocity (VdB)

Because of the difficulty in dealing with such an extreme range vibration amplitude which exist in nature, a compressed scale based on logarithms is used instead of the vibration amplitudes themselves, resulting in the "Vibration velocity level" in decibels (VdB).

$L_v = 20\ \log_{10}\left(\frac{v}{v_{ref}}\right)$	L_v = velocity level, VdB V = rms velocity amplitude (in/sec) V_{ref} = 10^{-6} in/sec in the United States

6 General Vibration Criteria

The response of buildings and the occupants to vibration is well-documented. General criteria and guidelines are widely available for acceptable vibration levels. The following section and subsections provide a general review of vibration criteria recommended by various federal agencies and professional organizations. The following figure illustrates common sources of vibration and the human and structural response to ground-born vibration, ranging from 50 VdB (below perceptibility) to 100 VdB (the threshold of potential building damage).

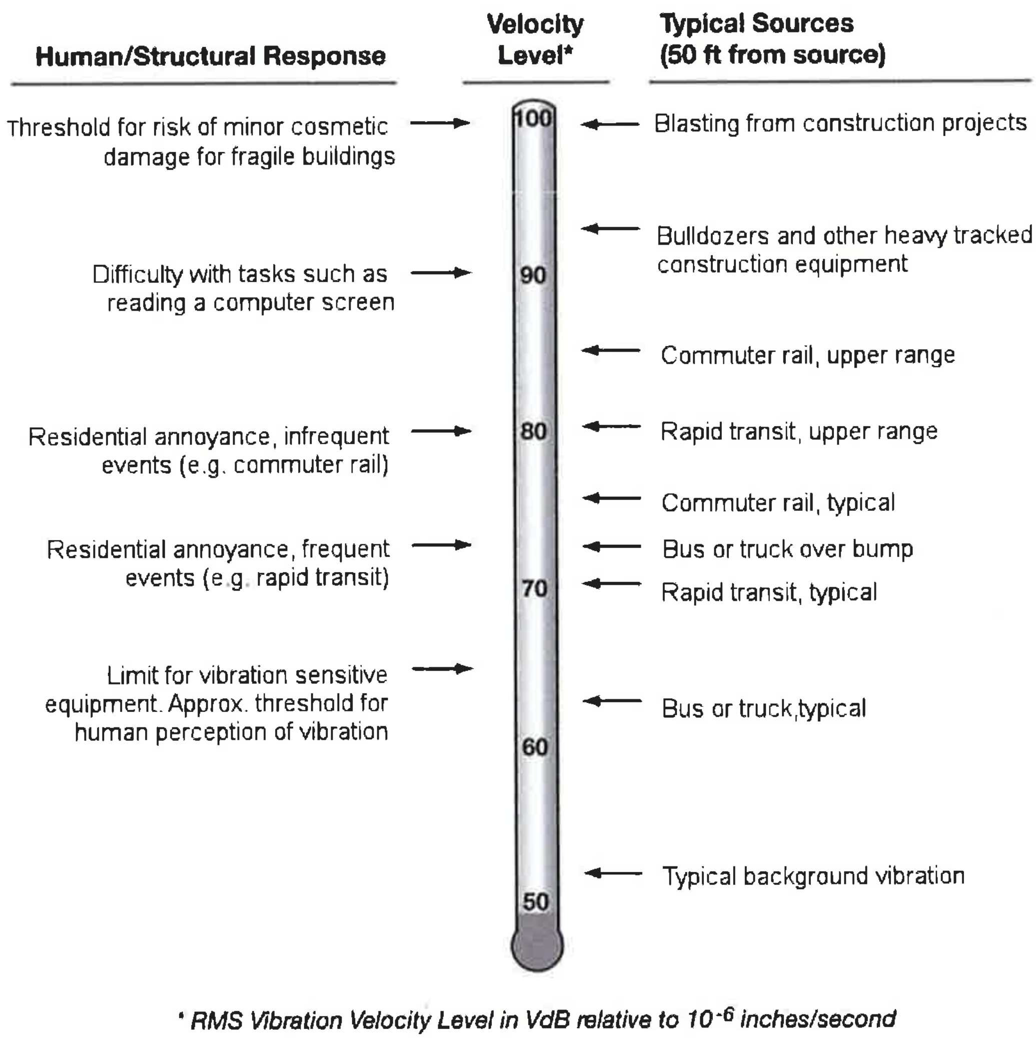

Figure 1 Typical Level of Ground-Borne Vibration (Federal Transit Administration 2018)

6.1 Vibration Criteria (Building Damage)

It is generally understood that when ground-borne vibration exceeds the perception level of building occupants, they will fear that damage to their property will occur.

6.1.1 Federal Transit Administration (FTA)

The 2018 version of the FTA's "Transit Noise and Vibration Impact Assessment Manual" notes that ground-borne vibration is a concern for nearby neighbors of a transit route. However, building damage due to vibration is rare for typical transportation projects. The following table provides the threshold for cosmetic damage.

Table 1 Federal Transit Administration Building Vibration Damage Criteria

Building / Structure Category	Peak Particle Velocity (in/sec)	Approximate Lv* (VdB)
Reinforced-concrete, steel or timber (no plaster)	0.5	102
Engineered concrete and masonry (no plaster)	0.3	98
Non-engineered timber ad masonry buildings	0.2	94
Buildings extremely susceptible to vibration damage	0.12	90

*Crest factor of 4 used calculate Lv from PPV level

6.1.2 American Association of State Highway and Transportation Officials (AASHTO)

The American Association of State Highway and Transportation Officials (AASHTO) (1990) identifies maximum vibration levels for preventing damage to structures.

Table 2 AASHTO Maximum Vibration Levels for Preventing Building Damage

Building Class	Peak Particle Velocity (in/sec)
Historic sites or other critical locations	0.1
Residential buildings, plastered walls	0.2 – 0.3
Residential buildings in good repair with gypsum board walls	0.4 – 0.5
Engineered structures, without plaster	1.0 – 1.5

6.1.3 Swiss Association of Standardization Vibration Damage Criteria

The Swiss Association of Standardization has developed a series of vibration damage criteria for continuous sources (machines and traffic). The following table shows the vibration criteria in the frequency range for traffic sources (10–30 Hz).

Table 3 Swiss Association of Standardization Building Vibration Damage Criteria

Building Class	Peak Particle Velocity (in/sec)
Class I: buildings in steel or reinforced concrete, such as factories, retaining walls, bridges, steel towers, open channels, underground chambers and tunnels with and without concrete alignment	0.5
Class II: buildings with foundation walls and floors in concrete, walls in concrete or masonry, stone masonry retaining walls, underground chambers and tunnels with masonry alignments, conduits in loose material	0.3
Class III: buildings as mentioned above but with wooden ceilings and walls in masonry	0.2
Class IV: construction very sensitive to vibration; objects of historic interest	0.12

6.1.4 National Cooperative Highway Research Program (Historic Structures Damage)

The National Cooperative Highway Research Program (NCHRP) funded research on vibration and potential effects on historic buildings adjacent to transportation projects (NCHRP 25-25/Task 72). The following table summarizes relevant vibration criteria for historic structures.

Table 4 National Cooperative Highway Research Program Summary of Vibration Limits

Reference Source	Remarks on Vibration Source	Remarks on Building or Structure	Remarks on Type of Damage	Vibration Limit - PPV (inches/sec)
British Standards Institute (1993)	All (including blasting)	Unreinforced or light framed structures	Cosmetic	0.6 to 2.0† (historic buildings may require special consideration)
Sedovic (1984)	All	Historic buildings in good state of maintenance	--	0.5
City of New York City (1988); Esrig and Ciancia (1981)	Blasting, pile driving and vehicular traffic	Structures which are designated NYC landmarks, or located within an historic district or listed on the NHRP	--	0.5
Whiffin and Leonard (1971)	Traffic	Buildings with plastered walls and ceilings	Architectural damage and risk of structural damage	0.4 to 0.6
Rudder (1978)	Traffic	All	Structural damage possible	0.4
City of Toronto (2008)	All (blasting not mentioned)	All buildings	--	0.3 to 1.0† (lower limits may be identified by professional engineer)
Federal Transit Administration (2006)	All	Non-engineered timber and masonry buildings	--	0.2
Sedovic (1984)	All	Historic or architecturally important buildings in deteriorated state of maintenance	--	0.2
Whiffin and Leonard (1971)	Traffic	Buildings with plastered walls and ceilings	Threshold of risk of architectural damage	0.2
Feilden (2003)	All	All buildings	Threshold for structural damage	0.2
Rudder (1978)	Traffic	All	Minor damage possible	0.2
Konon and Schuring (1985)	Steady state	Historic buildings	Cosmetic	0.12 to 0.4†
Deutsches Institut für Normung DIN 4150-3 (1999)	All	Buildings of great intrinsic value	Any permanent effect that reduces serviceability	0.12 to 0.4†
Federal Transit Administration (2006)	All	Buildings extremely susceptible to vibration	--	0.12
American Association of State Highway and Transportation Officials (2004)	All	Historic sites and other critical locations	Threshold for cracks (cosmetic)	0.12
Esteves (1978)	Blasting	Special care, historical	--	0.1 to 0.4††
Rudder (1978)	Traffic	All	Threshold of structural damage	0.1
Whiffin and Leonard (1971)	Traffic	Buildings with plastered walls and ceilings	Virtually no risk of architectural damage	0.1
Feilden (2003)	All	All buildings	Threshold for plaster cracking	0.08
Whiffin and Leonard (1971)	Traffic	Ruins and ancient monuments	--	0.08

† frequency-dependent criteria
†† depending on soil type and frequency

6.2 Vibration Criteria (Interior Occupant Impact)

The effects of ground-borne vibration can include perceptible movement of floors in buildings, rattling of windows, shaking of items on shelves or hanging on walls. Although the perceptibility threshold is approximately 65 VdB, human response to vibration is not usually substantial unless the vibration exceeds 70 VdB.

The following table presents the human response to different levels of ground-borne vibration on which the occupant impact criteria presented in the following section are based. Floor vibration in the Distinctly Perceptible range is unacceptable for a residence. Residential vibration exceeding 75 VdB is unacceptable for a repetitive vibration source such as rapid transit trains that pass every 5 to 15 minutes. A Transportation Research Board (TRB) study of human response to vibration from 2009 also supports this finding and indicates that incidence of complaints fall rapidly with a level decreasing below 72 VdB

Table 5 FTA Human Reponse to Different Levels of Ground-Borne Vibration

Vibration Velocity Level	Human Response
65 VdB	Approximate threshold of perception for many humans.
75 VdB	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find transit vibration at this level annoying.
85 VdB	Vibration tolerable only if there are an infrequent number of events per day.

6.2.1 Federal Transit Administration Indoor Vibration Impact Criteria (General Buildings)

The 2018 version of the FTA's "Transit Noise and Vibration Impact Assessment Manual" provides criteria regarding assessment of ground-borne vibration impact on the occupants of various types of buildings. These criteria are based on the frequency of events and use of the building. Impact will occur if these levels are exceeded. Criteria for ground-borne vibration are expressed in terms of rms velocity levels in VdB.

Table 6 FTA Indoor Vibration Occupant Impact Assement Criteria (General Buildings)

Land Use	Interior Ground-Borne Vibration Level Frequent Events More Than 70 Events Per Day (VdB re 1 micro-inch/sec)	Interior Ground-Borne Vibration Level Occasional Events 30 - 70 Events Per Day (VdB re 1 micro-inch/sec)	Interior Ground-Borne Vibration Level Infrequent Events Fewer Than 30 Events Per Day (VdB re 1 micro-inch/sec)
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB *	65 VdB *	65 VdB *
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB
*This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. For equipment that is more sensitive, a Detailed Vibration Analysis must be performed.			

6.2.2 Federal Transit Administration Indoor Vibration Impact Criteria (Special Use Buildings)

The 2018 version of the FTA's "Transit Noise and Vibration Impact Assessment Manual" provides criteria regarding assessment of ground-borne vibration impact on the occupants of special use building such as church auditoriums. These criteria are based on the frequency of events and use of the building. Impact will occur if these levels are exceeded. Criteria for ground-borne vibration are expressed in terms of rms velocity levels in VdB.

Table 7 FTA Indoor Vibration Occupant Impact Assement Criteria (Special Use Buildings)

Type of Building or Room	Interior Ground-Borne Vibration Level Frequent Events More Than 70 Events Per Day (VdB re 1 micro-inch/sec)	Interior Ground-Borne Vibration Level Occasional or Infrequent Events 70 Events Per Day or Less (VdB re 1 micro-inch/sec)
Concert Halls	65 VdB	65 VdB
TV studios	65 VdB	65 VdB
Recording Studios	65 VdB	65 VdB
Auditoriums	72 VdB	80 VdB
Theaters	72 VdB	80 VdB

7 Existing West Water Street Ground Vibration Measurements

7.1 Existing Ground Vibration Monitoring Procedure

Representatives of VTE performed 24 hours of continuous ambient ground vibration monitoring at three locations along West Water Street from Thursday, August 13, 2020 at 12:00 PM, through Friday, August 14, 2020 at 12:00 PM.

Vibra-Tech Multiseis digital triaxial seismographs were used to measure ground vibration. Vibration sensors were spiked into the soil six (6) feet from the curb. Seismographs were programed for high resolution mode at 1024 samples per second per channel and to log maximum peak particle velocity levels and corresponding frequencies at 15-second intervals for vertical and horizontal directions.

The following figure and table summarize the measurement locations. Three hundred and eighty-seven (387) vehicles were observed along West Water Street and Charles Street during the vibration monitoring period. No semi-trucks were observed, only passenger vehicles and 2-axle trucks.

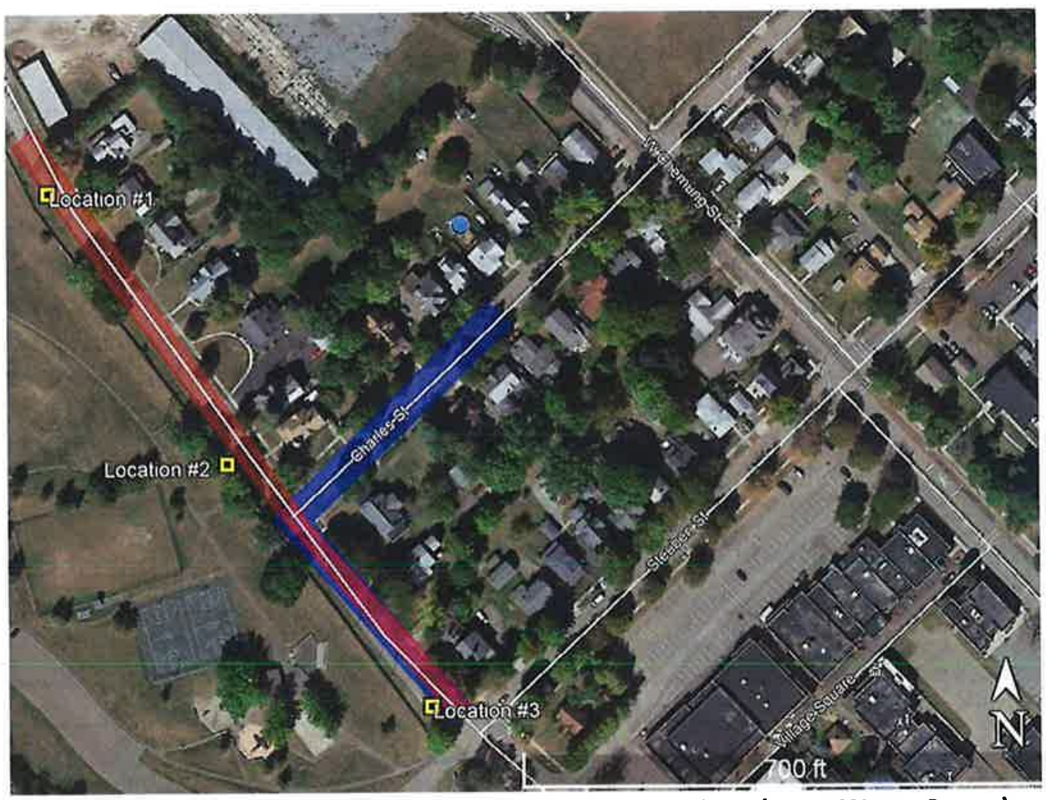

Figure 2 Ambient Ground Vibration Monitoring Locations (West Water Street)

Table 8 Ambient Ground Vibration Monitoring Locations

Location	Description	Nearby Residence Picture
1	Across Street From 342 W. Water St 6 feet from curb Road width 22 feet N 42° 9.636" W 77° 5.851" Seismograph Serial # BF21438	
2	Across Street From 302 W. Water St 6 feet from curb Road width 28 feet N 42° 9.579" W 77° 5.800" Seismograph Serial # BF11172 Seismograph Serial # BB8334	
3	Across Street From 204 W. Water St 6 feet from curb Road width 32 feet N 42° 9.528" W 77° 5.742" Seismograph Serial # BD6384	

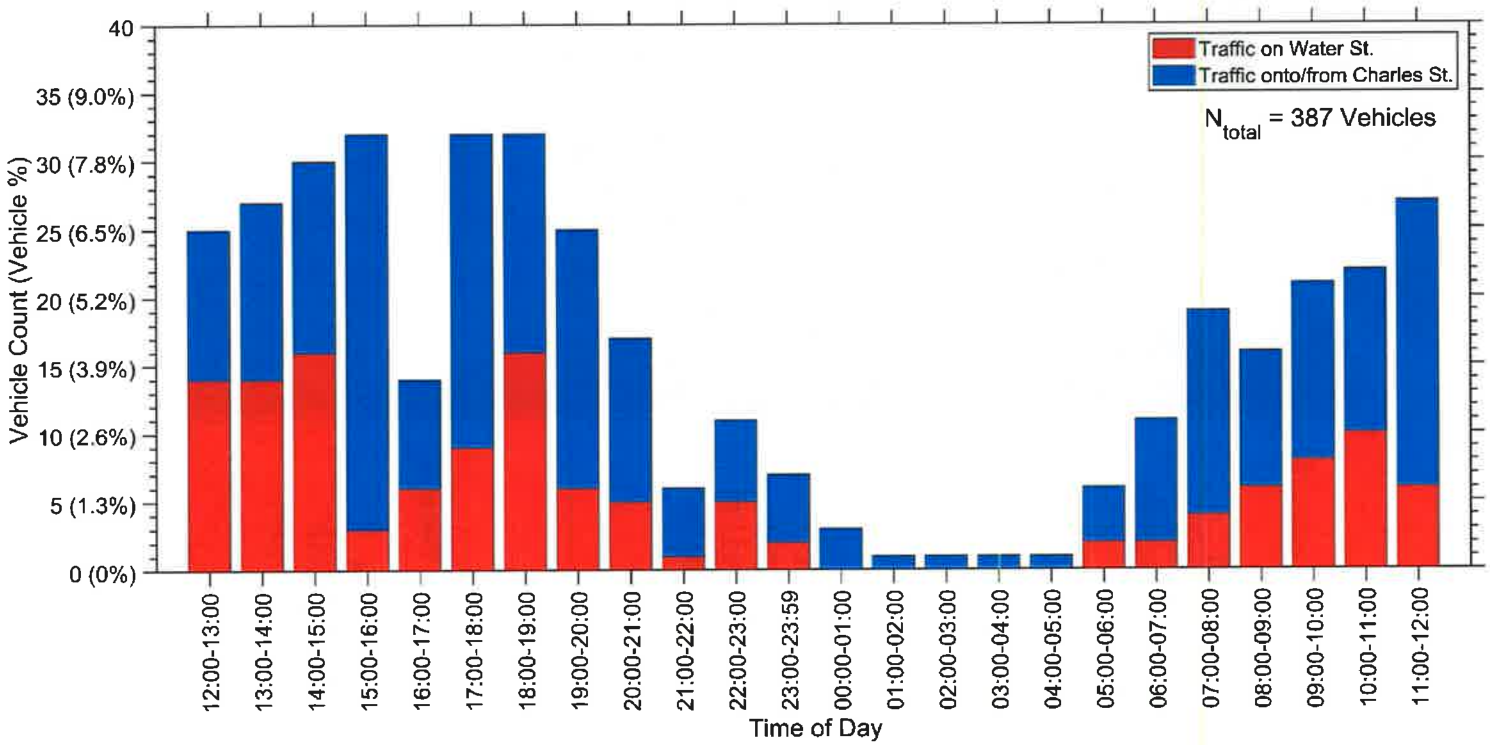

Figure 3 Observed Traffic During Ambient Vibration Monitoring Period

7.2 Existing Ground Vibration Monitoring Results

Existing vibration levels at the three West Water Street residences resulting from existing traffic induced vibration are below vibration damage and occupant impact criteria recommended by the FTA and various other government and academic organizations.

Table 9 Measured Ambient Ground Vibration Peak Particle Velocity Six Feet From Curb

Ambient Vibration Measurement Location	Minimum Ground Peak Particle Velocity Horizontal and Vertical PPV (in/sec)	Median (50%) Ground Peak Particle Velocity Horizontal and Vertical PPV (in/sec)	99 Percentile Ground Peak Particle Velocity Horizontal and Vertical PPV (in/sec)	Maximum Ground Peak Particle Velocity Horizontal and Vertical PPV (in/sec)	Below Vibration Damage Criteria
#1 - Across From 302 W. Water St	0.002	0.003	0.003	0.007	Yes
#2 - Across From 302 W. Water St	0.002	0.003	0.004	0.009	Yes
#3 - Across From 204 W. Water St	0.003	0.003	0.004	0.012	Yes

Table 10 Measured Ambient Ground Vibration RMS Level Six Feet From Curb*

Ambient Vibration Measurement Location	Minimum Ground Velocity RMS Level Horizontal and Vertical (VdB)	Median (50%) Ground Velocity RMS Level Horizontal and Vertical (VdB)	99 Percentile Ground Velocity RMS Level Horizontal and Vertical (VdB)	Maximum Ground Velocity RMS Level Horizontal and Vertical (VdB)	Below Building Occupant Vibration Impact Criteria
#1 - Across From 302 W. Water St	53	56	58	65	Yes
#2 - Across From 302 W. Water St	53	56	59	67	Yes
#3 - Across From 204 W. Water St	56	58	61	69	Yes

*Root Mean Square Level Calculated from Measured PPV Using FTA Recommendation of Crest Factor of 4

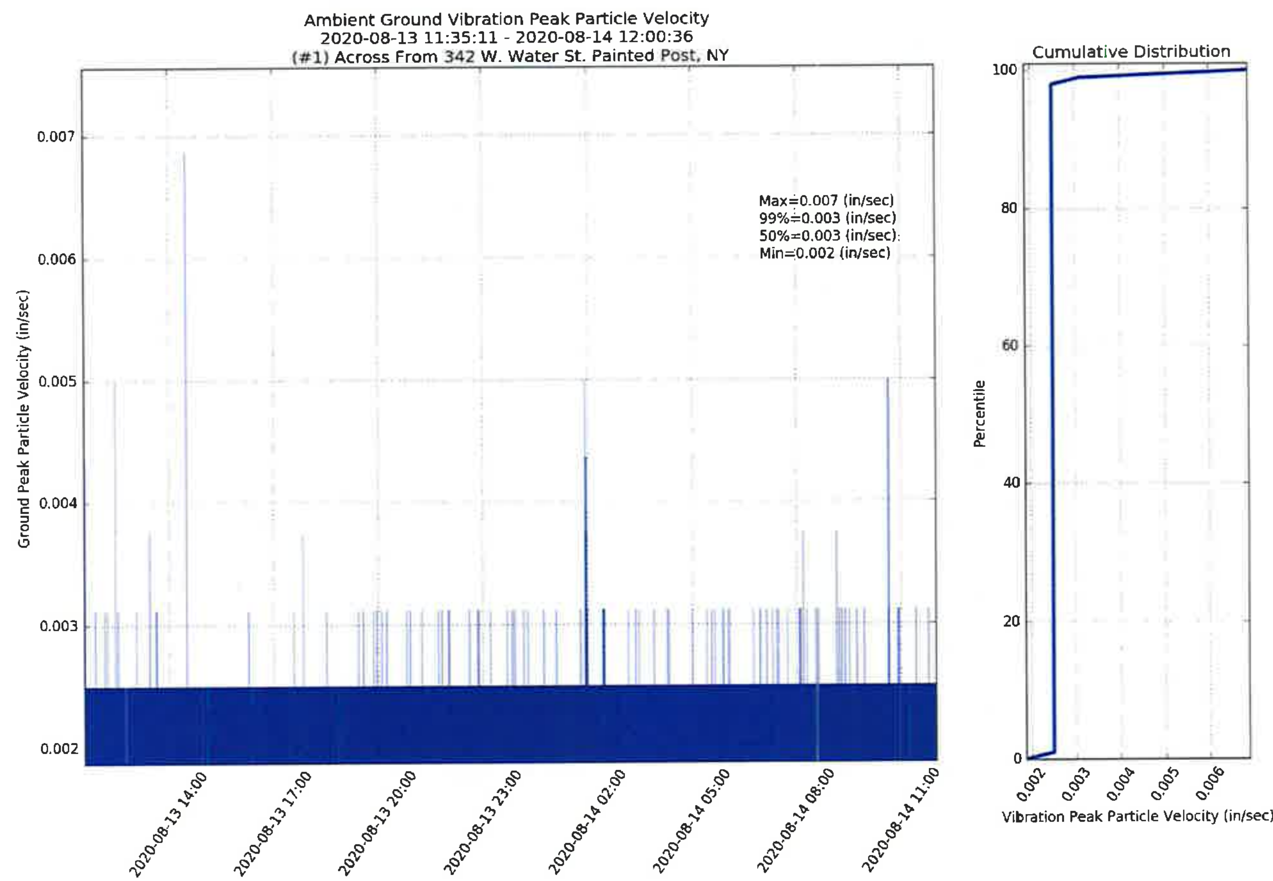

Figure 4 Location #1 Measured 24-Hour Ambient Ground Peak Particle Velocity (PPV)

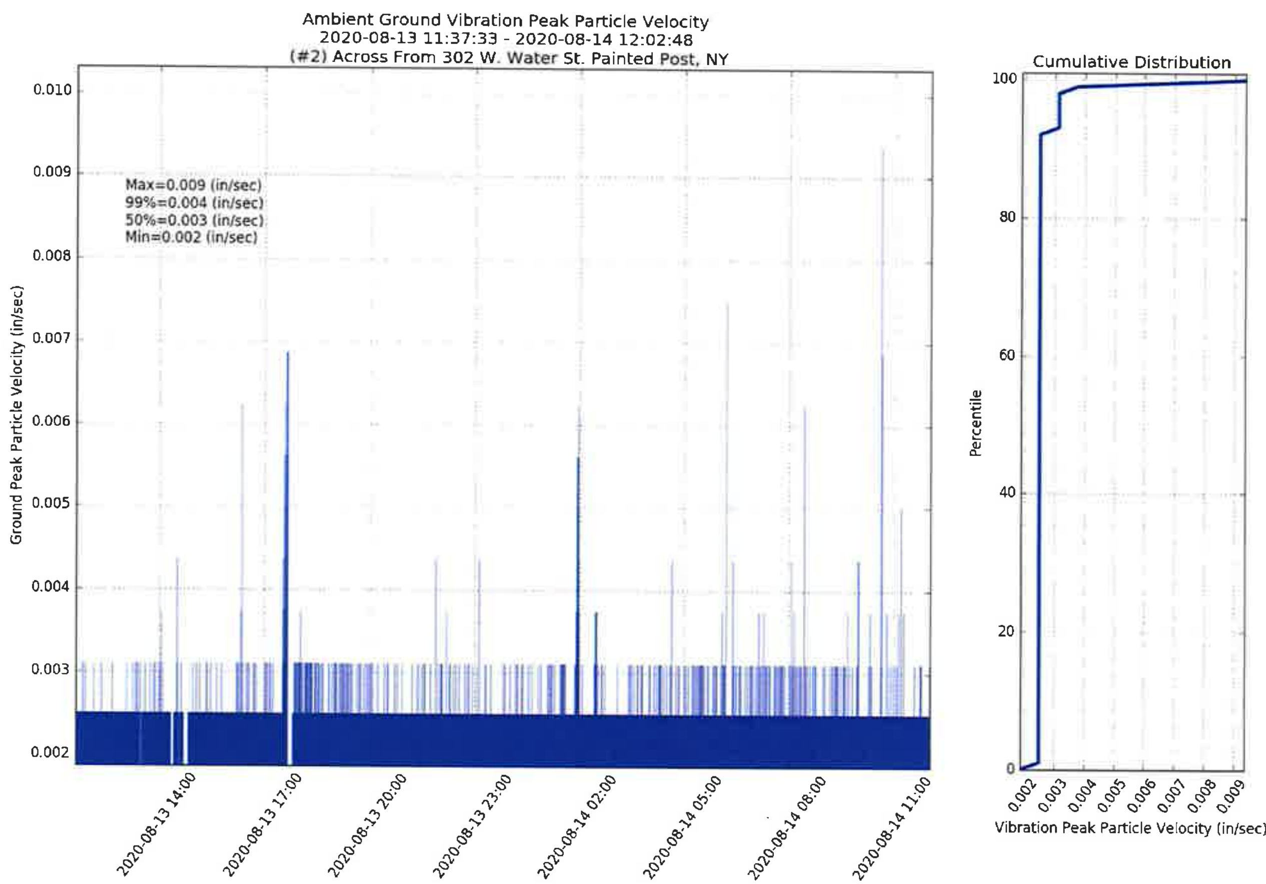

Figure 5 Location #2 Measured 24-Hour Ambient Ground Peak Particle Velocity (PPV)

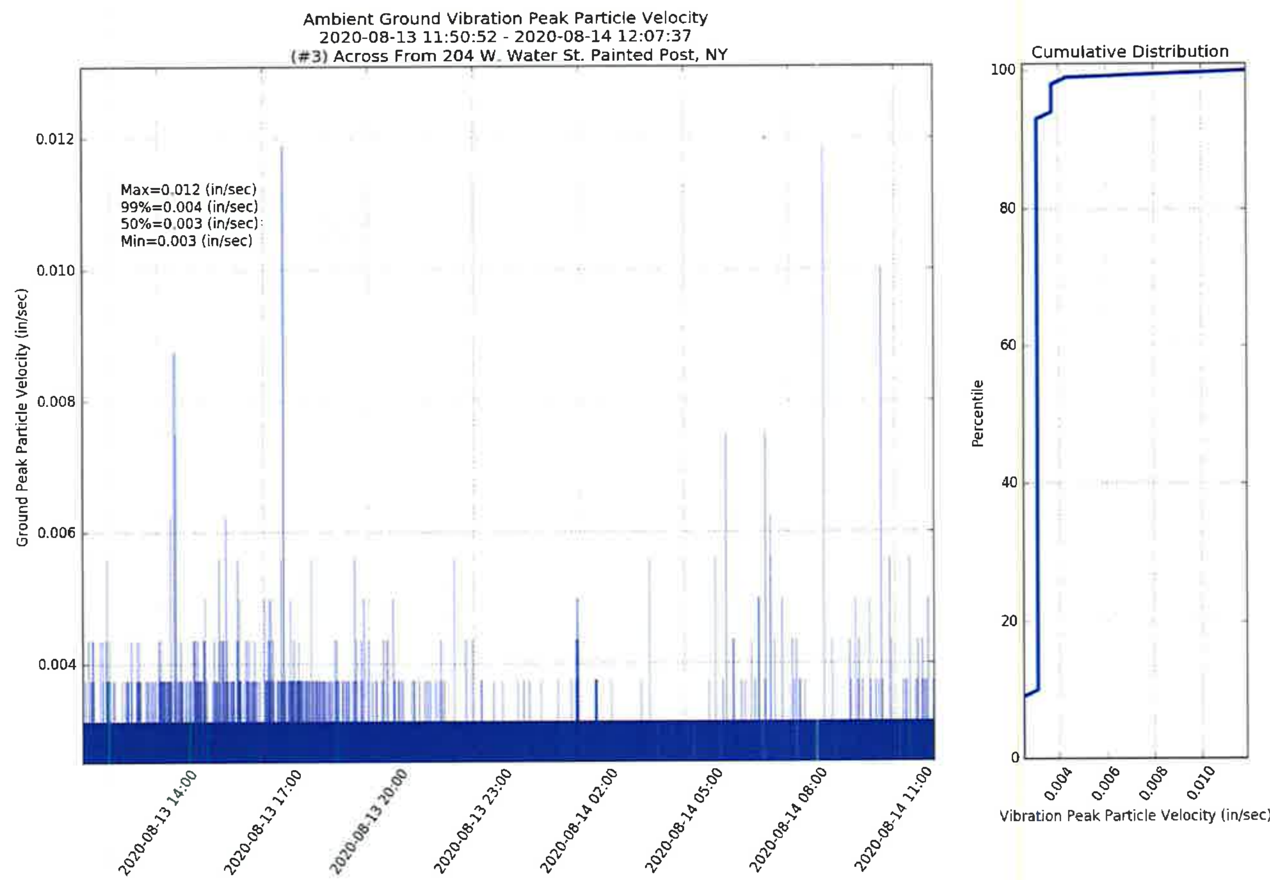

Figure 6 Location #3 Measured 24-Hour Ambient Ground Peak Particle Velocity (PPV)

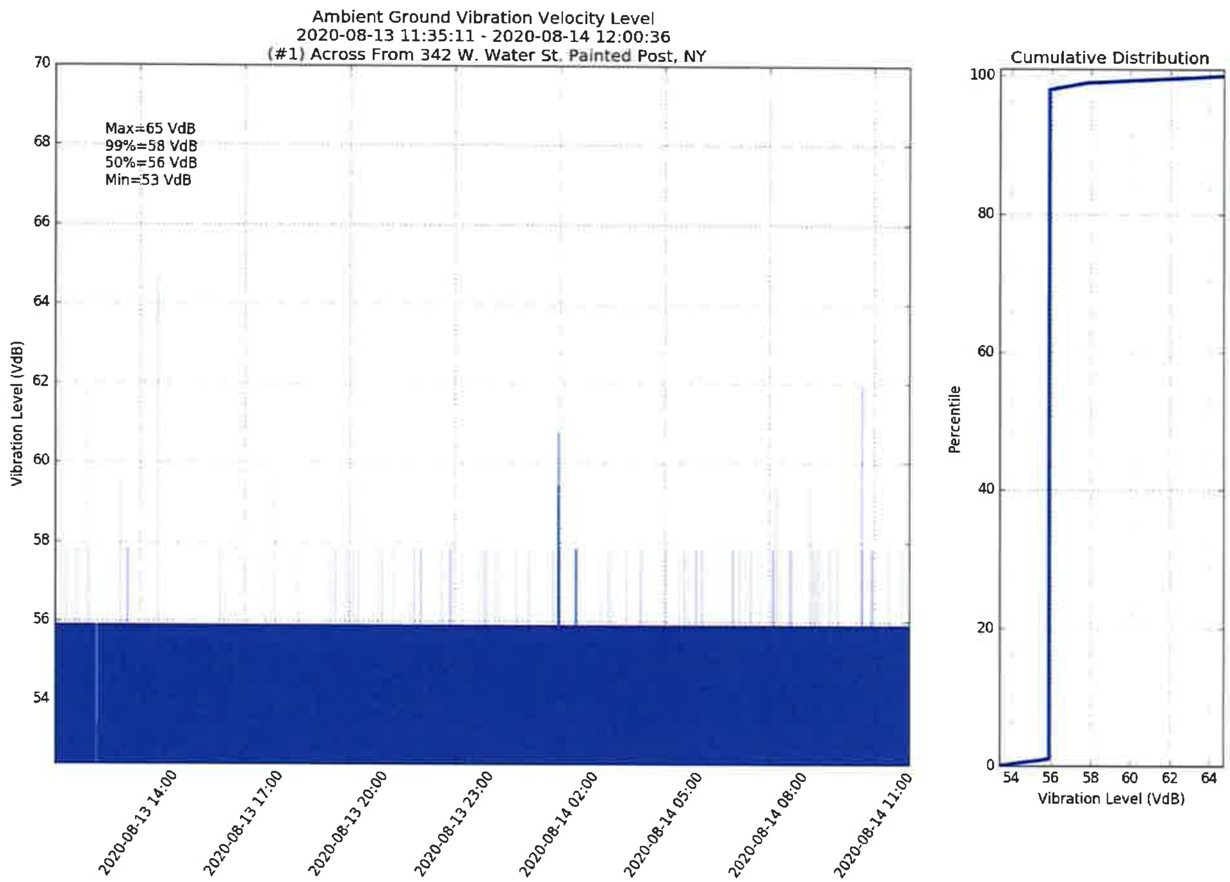

Figure 7 Location #1 Measured 24-Hour Ambient Ground RMS Level

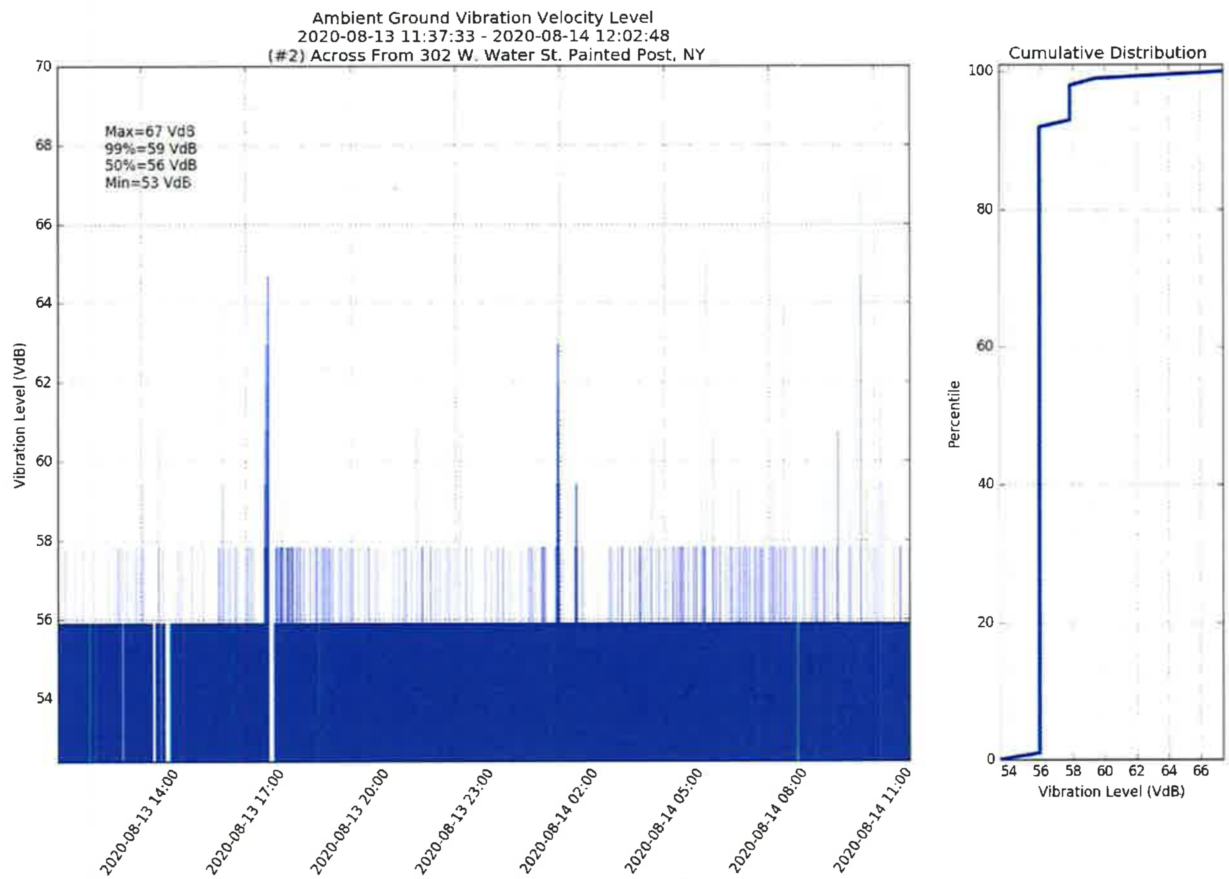

Figure 8 Location #2 Measured 24-Hour Ambient Ground RMS Level

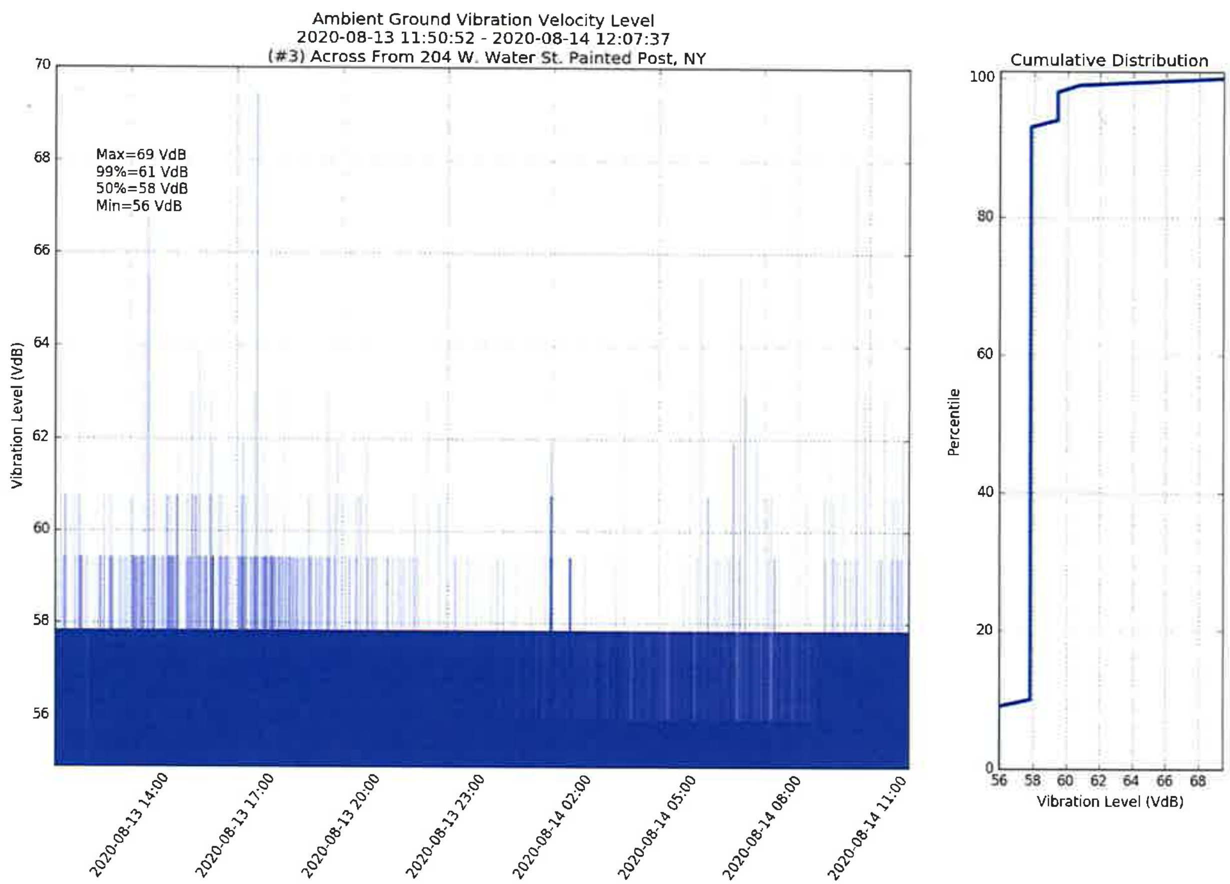

Figure 9 Location #3 Measured 24-Hour Ambient Ground RMS Level

8 Semi-Truck Ground Vibration Attenuation Measurements

8.1 Semi-Truck Induced Ground Vibration Attenuation Measurement Procedure

Representatives of VTE performed the measurement of ground vibration at various standoff distances from West Water Street during multiple passes of a loaded tractor-trailer. The tractor-trailer had a GVW of approximately 25,000lbs and the load was approximately 17,000lbs. Measurements were conducted on Thursday, December 10, 2020.

Vibration measurement were conducted along the west side of Charles Street from the intersection of West Water Street at Charles Street. An array of 10 digital seismographs were oriented in the easement extending from the curb to a 60-foot standoff.

Vibra-Tech Multiseis digital triaxial seismographs were used to measure ground vibration. Vibration sensors were spiked and buried 8 inches in the soil and spiked. Seismographs were programed for high resolution mode at 1024 samples per second per channel and to record for ten seconds during directed passes of the loaded tractor-trailer.

The ground vibration was recorded during multiple truck passes in both the eastbound and westbound directions. The truck passed at a speed of approximately 20 miles per hour.

The pavement at the monitoring location was smooth and in good condition. In order to simulate passing over a manhole or large pothole, 2"x10" planks were placed across water street and the vibration tests were repeated.

Figure 10 Seismic Array

Figure 11 Loaded Tractor-Trailer (42,000 lbs) Used In Testing

Figure 12 Seismic Array Location 302 W. Water St

Table 11 Seismograph Array Distance From Passing Truck

Seismograph Serial Number	Distance from West Bound Traveling Truck (Feet)	Distance from East Bound Traveling Truck (Feet)
BF16988	9.5	22
BF21449	19.5	32
BF12505	24.5	37
BF15874	29.5	42
BD7348	34.5	47
BF10321	39.5	52
BF13925	44.5	57
BD8469	49.5	62
BD7340	54.5	67
BF12504	59.5	72

Table 12 Seismograph Array Test

Test	Truck Travel Lane And Direction	Passing Over Simulated Pothole 2" x 10" Plank (Yes/No)	Truck Speed (Mph)
1	West Bound	Yes	18 mph
2	East Bound	Yes	20 mph
3	West Bound	Yes	21 mph
4	East Bound	Yes	20 mph
5	West Bound	No	20 mph
6	East Bound	No	20 mph
7	West Bound	No	21 mph
8	East Bound	No	22 mph
9	West Bound	Yes	19 mph
10	East Bound	Yes	21 mph
11	West Bound	No	20 mph
12	East Bound	No	20 mph
13	West Bound	Yes	18 mph
14	East Bound	Yes	20 mph

8.2 Seismic Array Results

Results of the measured ground attenuation during the passing of the loaded tractor-trailer are shown in the following figure. The 50% regression equation is shown in red, and the 99% prediction band for future ground vibration from passing loaded tractor trailers is shown in gray.

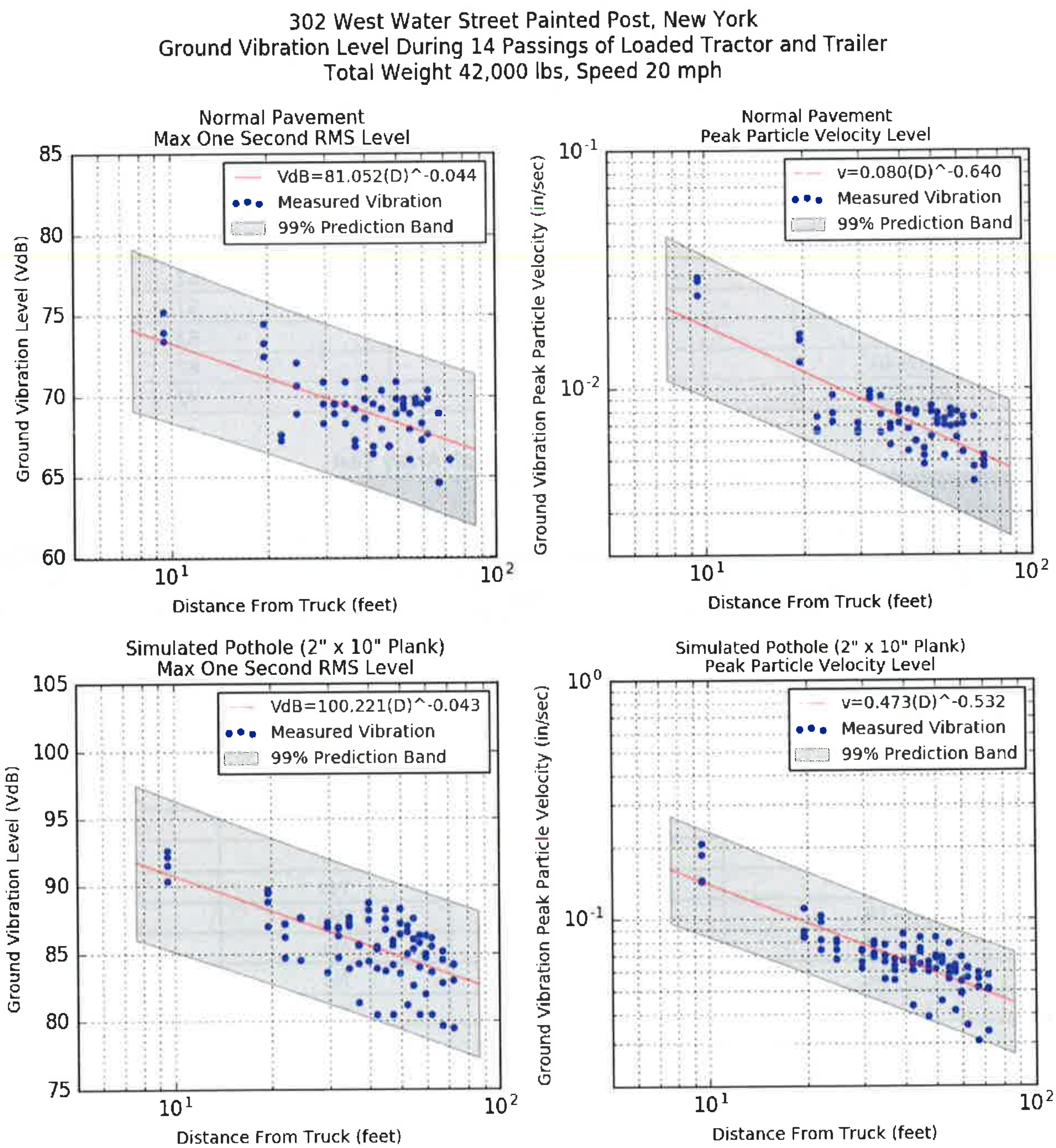

Figure 13 Measured Ground Vibration During 14 Passes of Loaded Tractor-Trailer

9 Future Vibration Levels During Warehouse Operation

The following section provides analysis of the vibration impacts of the proposed 600,000-square foot Tyoga Container Warehouse Facility at 450 West Water Street on the adjacent properties, and the vibration impact of semi-trucks passing the properties located along the West Water Street access road. This vibration impact study has been conducted based on guidelines provided by the FTA, FHWA, and ground vibration measurements recorded along West Water Street.

9.1 Warehouse Operations Vibration Impact

No manufacturing operations will occur at the proposed warehouse facility. Forklift drivers pull product from the warehouse and load trucks in the afternoon and evening. There are 91 trailer parking spaces and 60 loading dock spaces proposed. The closest building location will be approximately 100 feet from the residence at 324 West Water Street. The closest warehouse loading dock will be approximately 200 feet from the residence at 324 West Water Street.

The following tables show calculation of vibration levels due to loading dock activity. The vibration levels induced by loading dock operations at the closest residence, 324 West Water Street, are below vibration damage and occupant impact criteria recommended by various government and academic organizations. Vibration levels for residences at greater distances from the loading docks will also meet these vibration criteria.

Table 13 Warehouse Operations Vibration Damge to Building at 324 W. Water Street

Closest Residential Structure to Loading Dock	Distance from Loading Dock (feet)	Predicted Ground Vibration at Residence PPV (in/sec)	Below Residential Vibration Damage Criteria
324 W. Water St	200	0.005	yes

Table 14 Warehouse Operations Vibration Impact to Occupants of 324 W. Water Street

Closest Residential Structure to Loading Dock	Distance from Loading Dock (feet)	Predicted Interior Vibration Level of Residence (VdB)	Vibration Impact Criteria Level (VdB)	Below Residential Vibration Impact Criteria
324 W. Water St	200	68.1	Category 2: Residence where people normally sleep Frequent Events 72 VdB	yes

9.2 West Water Street Semi-Truck Traffic Vibration Impact

Approximately 100 single-pass semi-truck trips will occur per day on West Water Street to service the proposed warehouse facility. The following sections analyze the potential for vibration damage to the Water Street structures, and the vibration impact of semi-truck traffic on the occupants.

9.2.1 Vibration Damage of West Water Street Structures

The following table shows the predicted ground vibration peak particle velocity next to the foundation of the structures due to semi-truck traffic passing along West Water Street and compares these levels with damage limits provided in the vibration criteria section of this report. These predictions are based upon the field measurements of the passes of a loaded tractor-trailer taken by VTE.

Ground-borne vibration levels at all West Water Street structures induced by the passing semi-trucks are predicted to be significantly below the most stringent damage criteria for fragile and historic structures recommended by various government and academic organizations.

Table 15 West Water Street Structres Vibration Damage Potential from Semi-Truck Traffic

Address	Year Built	Type	Const	Story	Basement	Distance to Street (ft)	Predicted Ground Vibration at Structure PPV (in/sec)	Meets Vibration Damage Criteria
100 VILLAGE	1974	Commercial	--	1	No	144	0.007	YES
109 W WATER	1955	Commercial	Mas/Wood	2	Yes	47	0.013	YES
110 VILLAGE	1974	Commercial	--	1	No	128	0.007	YES
117 W WATER	1921	Multi-Use	Masonry	3	Half	56	0.012	YES
130 W WATER	1920	Religious	Masonry	1	Yes	54	0.012	YES
140 VILLAGE	1974	Commercial	Wood	1	No	110	0.008	YES
142 W WATER	1942	Residential	Wood	2	Yes	66	0.010	YES
143 VILLAGE	1974	Commercial	Wood	1	No	110	0.008	YES
204 W WATER	1822	Residential	Wood	2	Yes	43	0.014	YES
220 W WATER	1840	Residential	Wood	2	Yes	57	0.011	YES
240 W WATER	1925	Residential	Wood	2	Half	54	0.012	YES
302 W WATER	1895	Residential	Wood	2	Yes	36	0.015	YES
308 W WATER	1900	Residential	Wood	2	Yes	36	0.015	YES
314 W WATER	1860	Residential	Wood	2	Yes	68	0.010	YES
324 W WATER	1909	Residential	Wood	2	Yes	52	0.012	YES
330 W WATER	1927	Residential	Wood	2	Yes	55	0.012	YES
334 W WATER	1927	Residential	Wood	2	Yes	50	0.012	YES
342 W WATER	1900	Residential	Wood	2	Yes	51	0.012	YES

9.2.2 Vibration Impact to Occupants of West Water Street Structures

The following tables shows projected vibration impact to the of occupants of structures on West Water Street due to semi-truck traffic related to the operation of the proposed Tyoga Container Facility and compares the projected levels to the impact criteria provided by the FTA. These predictions are based upon the field measurements of the passes of a loaded tractor-trailer taken by VTE.

The proposed facility will create approximately 100 additional semi-truck passings along the West Water Street Access Road per day. The FTA vibration impact criteria for occupants of residential structures is most restrictive when then number of events exceeds 70 per day.

Ground-borne vibration levels inside four of the West Water Street residential structures induced by the passing trucks are predicted to be at the borderline of the FTA vibration impact criteria. Vibration levels are predicted to fall in the FTA designated "barely perceptible range." These residential structures are 54 feet or less from the roadway.

When the number of truck passes is reduced to 70 per day or less, ground-borne vibration levels inside all West Water Street residential and commercial structures induced by the passing trucks are predicted to meet the FTA vibration impact criteria.

Table 16 Predicted Vibration Impact to Occupants of Water Street Structures Semi-Truck Traffic More Than 70 Passes Per Day

Address	Year Built	Type	Const	Story	Basement	Distance to Street (ft)	Land Use Category	Indoor GBV Impact Criteria Frequent Events (VdB)	Total Building Transmission Adjustments Based on Construction (dB)	Predicted Interior Vibration Level (VdB)	Deficiency Criteria – Predicted Level (VdB)	Meets FTA Vibration Impact Criteria > 70 Passes Per Day
100 VILLAGE	1974	Commercial	--	1	No	144	Cat 3	75	1	70.9	4.1	YES
109 W WATER	1955	Commercial	Mas/Wood	2	Yes	47	Cat 3	75	-1	72.1	2.9	YES
110 VILLAGE	1974	Commercial	--	1	No	128	Cat 3	75	1	71.3	3.7	YES
117 W WATER	1921	Multi-Use	Masonry	3	Half	56	Cat 3	75	-5	67.6	7.4	YES
130 W WATER	1920	Religious	Masonry	1	Yes	54	Church	72	-6	66.7	5.3	YES
140 VILLAGE	1974	Commercial	Wood	1	No	110	Cat 3	75	1	71.7	3.3	YES
142 W WATER	1942	Residential	Wood	2	Yes	66	Cat 2	72	-1	71.1	0.9	YES
143 VILLAGE	1974	Commercial	Wood	1	No	110	Cat 3	75	1	71.7	3.3	YES
204 W WATER	1822	Residential	Wood	2	Yes	43	Cat 2	72	-1	72.4	-0.4	NO
220 W WATER	1840	Residential	Wood	2	Yes	57	Cat 2	72	-1	71.6	0.4	YES
240 W WATER	1925	Residential	Wood	2	Half	54	Cat 2	72	0	72.7	-0.7	NO
302 W WATER	1895	Residential	Wood	2	Yes	36	Cat 2	72	-1	72.9	-0.9	NO
308 W WATER	1900	Residential	Wood	2	Yes	36	Cat 2	72	-1	72.9	-0.9	NO
314 W WATER	1860	Residential	Wood	2	Yes	68	Cat 2	72	-1	71	1	YES
324 W WATER	1909	Residential	Wood	2	Yes	52	Cat 2	72	-1	71.8	0.2	YES
330 W WATER	1927	Residential	Wood	2	Yes	55	Cat 2	72	-1	71.7	0.3	YES
334 W WATER	1927	Residential	Wood	2	Yes	50	Cat 2	72	-1	71.9	0.1	YES
342 W WATER	1900	Residential	Wood	2	Yes	51	Cat 2	72	-1	71.9	0.1	YES

Table 17 Predicted Vibration Impact to Occupants of Water Street Structures Semi-Truck Traffic Less Than 71 Passes Per Day

Address	Year Built	Type	Const	Story	Basement	Distance to Street (ft)	Land Use Category	Indoor GBV Impact Criteria Frequent Events (VdB)	Total Building Transmission Adjustments Based on Construction (dB)	Predicted Interior Vibration Level (VdB)	Deficiency Criteria – Predicted Level (VdB)	Meets FTA Vibration Impact Criteria < 71 Passes Per Day
100 VILLAGE	1974	Commercial	--	1	No	144	Cat 3	78	1	70.9	7.1	YES
109 W WATER	1955	Commercial	Mas/Wood	2	Yes	47	Cat 3	78	-1	72.1	5.9	YES
110 VILLAGE	1974	Commercial	--	1	No	128	Cat 3	78	1	71.3	6.7	YES
117 W WATER	1921	Multi-Use	Masonry	3	Half	56	Cat 3	78	-5	67.6	10.4	YES
130 W WATER	1920	Religious	Masonry	1	Yes	54	Church	80	-6	66.7	13.3	YES
140 VILLAGE	1974	Commercial	Wood	1	No	110	Cat 3	78	1	71.7	6.3	YES
142 W WATER	1942	Residential	Wood	2	Yes	66	Cat 2	75	-1	71.1	3.9	YES
143 VILLAGE	1974	Commercial	Wood	1	No	110	Cat 3	78	1	71.7	6.3	YES
204 W WATER	1822	Residential	Wood	2	Yes	43	Cat 2	75	-1	72.4	2.6	YES
220 W WATER	1840	Residential	Wood	2	Yes	57	Cat 2	75	-1	71.6	3.4	YES
240 W WATER	1925	Residential	Wood	2	Half	54	Cat 2	75	0	72.7	2.3	YES
302 W WATER	1895	Residential	Wood	2	Yes	36	Cat 2	75	-1	72.9	2.1	YES
308 W WATER	1900	Residential	Wood	2	Yes	36	Cat 2	75	-1	72.9	2.1	YES
314 W WATER	1860	Residential	Wood	2	Yes	68	Cat 2	75	-1	71	4	YES
324 W WATER	1909	Residential	Wood	2	Yes	52	Cat 2	75	-1	71.8	3.2	YES
330 W WATER	1927	Residential	Wood	2	Yes	55	Cat 2	75	-1	71.7	3.3	YES
334 W WATER	1927	Residential	Wood	2	Yes	50	Cat 2	75	-1	71.9	3.1	YES
342 W WATER	1900	Residential	Wood	2	Yes	51	Cat 2	75	-1	71.9	3.1	YES

10 Conclusion

This vibration impact study has been conducted based on guidelines provided by the Federal Transportation Administration, The Federal Highway Administration, and ground vibration measurements recorded along West Water Street.

The following conclusions are made from this report:

1. The proposed warehouse facility will replace the former Ingersoll-Rand Foundry Site. No manufacturing operations will occur at the site. Semi-truck traffic traveling along West Water Street access road is the only anticipated source of vibration activity.

2. The closest warehouse loading dock will be approximately 200 feet from the nearest residence at 324 West Water Street. The predicted vibration at this residence induced by loading dock operations is below building damage and occupant impact vibration criteria recommended by the FTA. Vibration levels for residences at greater distances from the loading docks will also meet these vibration criteria.

3. VTE performed 24 hours of continuous ground vibration monitoring at three locations along West Water Street from Thursday, August 13, 2020 at 12:00 PM, through Friday, August 14, 2020 at 12:00 PM. No semi-truck traffic was observed on West Water Street during this period, only passenger vehicles and two-axle work trucks. Existing vibration levels resulting from traffic induced vibration are below vibration damage and occupant impact criteria recommended by the FTA.

4. VTE performed the measurement of ground vibration at 10 standoff distances from West Water Street during 14 passes of a loaded tractor-trailer. The tractor-trailer had a GVW of approximately 25,000lbs, with a load of approximately 17,000lbs. The truck traveled at about 20 mph during the testing. Based on these measurements the rate of ground vibration attenuation with distance from passing tractor and trailers was determined.

5. The proposed warehouse facility will create approximately 100 additional semi-truck passings along the West Water Street Access Road per day. The FTA vibration impact criteria for occupants of residential structures is most restrictive when then number of events exceeds 70 per day.

6. Based on our measurements of loaded truck passings, ground-borne vibration levels inside four of the West Water Street residential structures induced by the passing trucks are predicted to be at the borderline of the FTA vibration impact criteria. Vibration levels are

predicted to fall in the FTA designated "barely perceptible range." These residential structures are 54 feet or less from the roadway.

7. When the number of truck passes is reduced to 70 per day or less, ground-borne vibration levels inside all West Water Street residential and commercial structures induced by the passing trucks are predicted to meet the FTA vibration impact criteria.

8. Based on our measurements of loaded truck passings, ground-borne vibration levels induced by the passing trucks at all West Water Street structures are predicted to be significantly below the most stringent damage criteria for fragile and historic structures recommended by various government and academic organizations, regardless of the number of passes.

Respectfully Submitted,

Vibra-Tech Engineers, Inc.

Brian Warner

Brian Warner
Acoustic/Vibration Data Analyst

Ethan Huff
Project Manager

11 Appendix A: Structures Along West Water Street

Figure 14 100 Village Square

Figure 15 109 W. Water Street

Figure 16 110 Village Square

Figure 17 117 W. Water Street

Figure 18 130 W. Water Street

Figure 19 140 Village Square

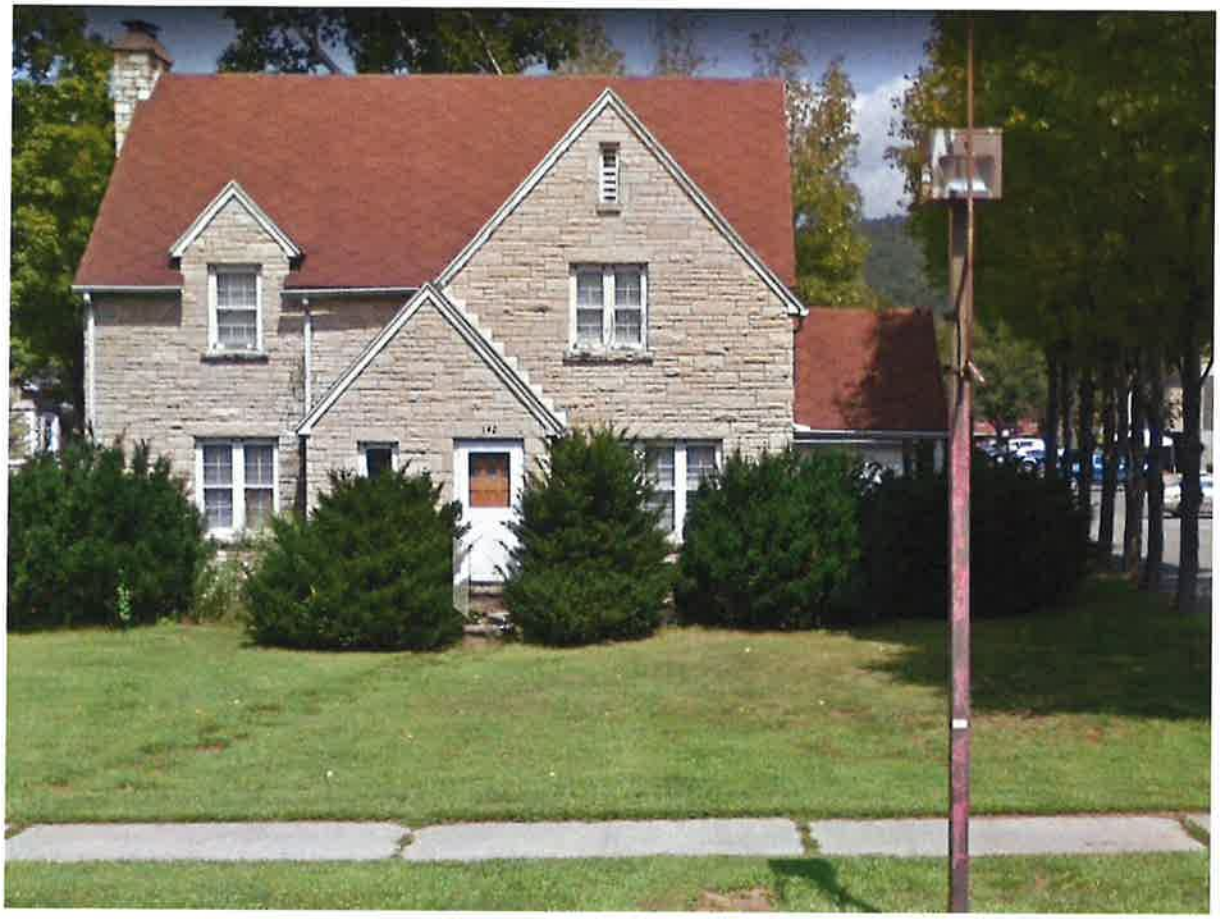

Figure 20 142 W. Water Street

Figure 21 143 Village Square

Figure 22 204 W. Water Street

Figure 23 220 W. Water Street

Figure 24 240 W. Water Street

Figure 25 302 W. Water Street

Figure 26 308 W. Water Street

Figure 27 314 W. Water Street

Figure 28 324 W. Water Street

Figure 29 330 W. Water Street

Figure 30 334 W. Water Street

Figure 31 342 W. Water Street