Section 4.12
Vibration

Contents

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Acronyms and Abbreviations

BRT ..... Bus Rapid Transit
FTA ..... Federal Transit Administration
LRT ..... Light Rail Transit
Lv ..... Velocity
Metro ..... Niagara Frontier Transit Metro System, Inc
Metro Rail ..... Metro Light Rail Transit System
UB ..... University at Buffalo
VdB ..... Vibration Decibels

4. Environmental Consequences

4.12 VIBRATION

This section presents the results of the operational vibration analysis for the Project. Measures to avoid, minimize, and mitigate vibration impacts are also included. Section 4.17, "Construction Effects," presents an analysis of vibration impacts during construction, and Section 4.11, "Noise," addresses the assessment of potential noise impacts associated with the Project.

Ground-borne vibration can be caused by the vibration of a transit structure, creating vibration waves that propagate through the soil and rock to the foundations of nearby buildings. The vibration of floors and walls may cause perceptible vibration, rattling of items such as windows or dishes on shelves, a rumble noise, or damage to buildings in extreme cases. Vibration is described in terms of velocity (Lv) and is measured in decibels (VdB), which is the root mean square vibration velocity relative to 1 microinch per second (FTA 2018). Table 4.12-1 summarizes the vibration impact findings.

Table 4.12-1. Vibration and Ground-borne Noise Impact Summary

Alternative	Permanent Vibration Impacts	Permanent Ground-borne Noise Impacts
No Build Alternative	No Impacts	No Impacts
LRT Build Alternative	Vibration impacts at 4 sensitive receptors No impact after mitigation	Ground-borne impacts at 6 sensitive receptors No impact after mitigation
BRT Build Alternative	No Impacts	No Impacts

For an overview of the regulatory context, methodology, and existing conditions see Appendix D7, "Noise and Vibration Supplemental Information".

4.12.1 No Build Alternative

The No Build Alternative would consist of a future scenario without the Project and would be implemented in the context of several unrelated future residential and mixed-use development projects along the corridor, which are expected to be developed regardless of the selected Project alternative. Ground-borne noise and vibration levels would be expected to be similar to or the same as the existing conditions.

4.12.2 LRT Build Alternative

The LRT Build Alternative would introduce new ground-borne noise and vibration sources into the environment, which could affect sensitive receptors. Primary vibration impacts result from the movement of light rail vehicles, which are supported by wheels on steel rail. Any discontinuity between the steel rail and the wheel can cause vibration, which is transmitted into

the ground by the support system for the rails. Even the smallest amount of discontinuity can result in elevated vibration. The transmission of vibration to the surrounding environment depends on how the rail system is supported and geological ground conditions.

The LRT Build Alternative would extend the existing Metro Rail from the City of Buffalo into the towns of Amherst and Tonawanda, consisting of an underground section from the existing UB South Campus station to a tunnel portal on Niagara Falls Boulevard between Kenilworth and Princeton Avenues, followed by at-grade track construction along the remainder of the Project alignment, except for a grade-separated section at the intersection of Maple Road and Sweet Home Road. The anticipated frequency of rail activity associated with the schedule of the Project would classify in the "frequent events" category as described in FTA vibration assessment procedures and shown in Appendix D7, "Noise and Vibration Supplemental Information". The LRT Build Alternative would use standard procedures for reducing vibration as described in section 4.12.4. Metro incorporated the trackwork and vehicle construction and preventative maintenance measures into the vibration analysis assumptions about the location and magnitude of potential impacts.

As described previously, several receptors are located within the screening distance from the LRT Build Alternative. Consequently, a general vibration analysis was conducted for the 26 receptors that represent the locations most likely to experience vibration or ground-borne noise impacts. Table 4.12-2 and Table 4.12-3 show the general analysis results. Vibration and ground-borne noise levels resulting from rail activity for these receptors were calculated using the general vibration assessment methodology described in Appendix D7, "Noise and Vibration Supplemental Information".

Table 4.12-2. LRT Build Alternative Vibration Impact Assessment Summary

Receptor	Location	Distance from Closest Rail (feet)	Vibration Levels (VdB)		
			Impact Threshold	Rail Generated Level	Impact or No Impact
1	Department of Oral Biology, UB South Campus	274	65	40	No Impact
2	School of Dental Medicine, UB South Campus	292	65	39	No Impact
3	Allen Hall, UB South Campus	130	65	48	No Impact
4	Cornerstone Community Church	93	75	57	No Impact
5	Residences on Kenmore Avenue at Niagara Falls Boulevard	44	72	80	Impact
6	252 Niagara Falls Boulevard	62	72	79	Impact
7	Trinity United Methodist Church	65	75	70	No Impact
8	Christian Fellowship Baptist Church	74	75	69	No Impact
9	800 Niagara Falls Boulevard	72	75	72	No Impact
10	839 Niagara Falls Boulevard	110	75	69	No Impact
11	885 Niagara Falls Boulevard	105	75	66	No Impact
12	1280 Sweet Home Road	162	72	59	No Impact
13	Hadley Village 110	122	72	59	No Impact
14	Cook Hall, UB North Campus	100	65	60	No Impact
15	Park Hall, UB North Campus	110	65	60	No Impact
16	Lockwood Memorial Library, UB North Campus	76	75	63	No Impact
17	Baird Hall, UB North Campus	91	65	61	No Impact
18	Slee Hall, UB North Campus	288	65	49	No Impact
19	Center for the Arts, UB North Campus	482	65	42	No Impact
20	Davis Hall, UB North Campus	295	65	49	No Impact
21	Greiner Hall, UB North Campus	255	72	51	No Impact
22	Mechanical and Astrospace Engineering, UB North Campus	288	65	49	No Impact
23	25 Bluebird Lane	79	72	74	Impact
24	Muir Woods Future Residential Development	114	72	61	No Impact
25	Residences along Homecrest Drive	267	72	64	No Impact
27	1185 Sweet Home Road	96	72	75	Impact

Note: Receptor 26 represented a potential future receptor that was removed from the analysis.

Table 4.12-3. LRT Build Alternative Ground-Borne Noise Impact Assessment Summary

Receptor	Location	Distance from Closest Rail (feet)	Ground-Borne Noise Levels (VdB)		
			Impact Threshold	Rail Generated Level	Impact or No Impact
1	Department of Oral Biology, UB South Campus	274	40	20	No Impact
2	School of Dental Medicine, UB South Campus	292	40	19	No Impact
3	Allen Hall, UB South Campus	130	25	28	Impact
4	Cornerstone Community Church	93	40	37	No Impact
5	Residences on Kenmore Avenue at Niagara Falls Boulevard	44	35	45	Impact
6	252 Niagara Falls Boulevard	62	35	44	Impact
7	Trinity United Methodist Church	65	40	35	No Impact
8	Christian Fellowship Baptist Church	74	40	34	No Impact
9	800 Niagara Falls Boulevard	72	40	37	No Impact
10	839 Niagara Falls Boulevard	110	40	34	No Impact
11	885 Niagara Falls Boulevard	105	40	31	No Impact
12	1280 Sweet Home Road	162	35	24	No Impact
13	Hadley Village 110	122	35	24	No Impact
14	Cook Hall, UB North Campus	100	40	25	No Impact
15	Park Hall, UB North Campus	110	40	25	No Impact
16	Lockwood Memorial Library, UB North Campus	76	40	28	No Impact
17	Baird Hall, UB North Campus	91	25	26	Impact
18	Slee Hall, UB North Campus	288	40	14	No Impact
19	Center for the Arts, UB North Campus	482	40	7	No Impact
20	Davis Hall, UB North Campus	295	40	14	No Impact
21	Greiner Hall, UB North Campus	255	35	16	No Impact
22	Mechanical and Astrospace Engineering, UB North Campus	288	40	14	No Impact
23	25 Bluebird Lane	79	35	39	Impact
24	Muir Woods Future Residential Development	114	35	26	No Impact
25	Residences along Homecrest Drive	267	35	29	No Impact
27	1185 Sweet Home Road	96	35	40	Impact

Note: Receptor 26 represented a potential future receptor that was removed from the analysis.

Table 4.12-2 and Table 4.12-3 show that the vibration levels and ground-borne noise predicted to result from operation of the LRT Build Alternative would not exceed FTA vibration or ground-borne noise impact criteria at Receptors 1, 2, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, or 25. Table 4.12-2 shows that predicted vibration levels would exceed applicable vibration impact criteria at Receptors 5, 6, 23, and 27. And Table 4.12-3 shows that predicted ground-borne noise levels would exceed applicable ground-borne noise impact criteria at Receptors 3, 5, 6, 17, 23, and 27.

- Receptor 3 represents Alan Hall on the UB South Campus, which contains a music performance hall and is consequently sensitive to ground-borne noise. The predicted ground-borne noise levels at this receptor would constitute the potential for an adverse impact.
- Receptor 5 represents residences on Kenmore Avenue at Niagara Falls Boulevard that would be within 140 feet of underground track. The predicted vibration and ground-borne noise levels at this receptor would constitute the potential for an adverse impact at these residences.
- Receptor 6 represents residences on Niagara Falls Boulevard that would be within 165 feet of at-grade track. The predicted vibration and ground-borne noise levels at this receptor would constitute the potential for an adverse impact at these residences.
- Receptor 17 represents Baird Hall on the UB North Campus, which contains two multiuse rehearsal halls and a music performance hall and is consequently especially sensitive to ground-borne noise. The predicted ground-borne noise levels at this receptor would constitute the potential for an adverse impact at this building.
- Receptor 23 represents residences along the east side of John James Audubon Parkway between Dodge Road and the Amherst Police Station that would be within 160 feet of at-grade track. The predicted vibration and ground-borne noise levels at this receptor would constitute the potential for an adverse impact at these residences.
- Receptor 27 represents residences at The Station Buffalo, located within 160 feet from the at-grade track. The predicted vibration and ground-borne noise levels at this receptor would constitute the potential for an adverse impact at these residences.

Prior to this impact assessment, Metro identified the following UB North Campus buildings as containing specialized vibration-sensitive research or equipment. Receptors 14, 15, 17, 18, 19, 20, and 22 are UB North Campus buildings that could contain specialized vibration-sensitive research or equipment, are described as follows:

- **Bonner Hall** – Electro Chemistry System, Atomic Force Microscope, Atom Probe Tomography, Bio Design Core System, Mass Spectrometer
- **Davis Hall** – Clean Room, Scanning Electron Microscopes
- **Furnas Hall** – Atomic Force Microscopes, Material Characterization Laboratory, Identity Governance and Administration System, Electrophysiology Experiments, and General Microscopes

Although these receptors were evaluated using the FTA's general assessment and vibration impact criteria for Land Use Category 1 (High Sensitivity) and found to have no vibration impacts, the vibration-sensitive equipment or procedures in these buildings may be more sensitive than a Category 1 receptor. To determine the potential for impacts at these more sensitive uses, more detailed study would be required. This detailed study requires Project design to advance to its final stages and is not possible at the current stage of Project design. Consequently, further study of potential vibration impacts would be undertaken during the final Project design to determine which mitigation measures would be necessary to avoid impacts at especially vibration-sensitive uses at UB North Campus.

Section 4.12.4 discusses additional mitigation approaches for addressing highly sensitive equipment or procedures for consideration during final design. The adverse impacts from vibration and ground-borne noise discussed above are compared to the thresholds for human perceptibility or annoyance as defined in Tables L-5 and L-6 in Appendix D7, "Noise and Vibration Supplemental Information". These thresholds are based on the receptor's land use and are more sensitive (lower) than the 90 vibration velocity (VdB) threshold used for evaluation of potential damage to extremely fragile or susceptible buildings (*e.g.*, historical buildings) provided by the FTA Guidance Manual and summarized in Table L-10. At all receptors analyzed, the calculated vibration levels due to the LRT Build Alternative shown in Table 4.12-2 are well below the 90 VdB threshold for damage to extremely fragile or susceptible buildings. Therefore, while vibration or ground-borne noise may be perceptible at Receptors 3, 5, 6, 17, 23, and 27, the vibration would not be at a level that is capable of causing damage at any receptor analyzed.

4.12.3 BRT Build Alternative

The expected vibration levels due to the BRT Build Alternative are lower than those discussed for the LRT Build Alternative. In addition, the FTA Guidance Manual indicates that other than projects that include vehicles operating within buildings or over roadway surface irregularities, projects that involve rubber-tired vehicles (i.e., BRT) are not expected to result in significant vibration impacts at receptors not considered highly sensitive. While vibration-sensitive research uses were identified on the UB North Campus, existing bus service already traverses campus and is comparable to the BRT Build Alternative. As such, the BRT Build Alternative will not interfere with vibration-sensitive research. Based on the results of the general vibration assessment and the expectation that vibration mitigation measures would be implemented for especially vibration-sensitive equipment as necessary, the BRT Build Alternative would not result in any adverse vibration or ground-borne noise impacts at these receptor sites.

4.12.4 Potential Mitigation Strategies

This section describes mitigation strategies to avoid, minimize, and mitigate the potential for vibration impacts associated with the Project.

4.12.4.1 LRT Build Alternative

The LRT Build Alternative would use standard procedures for reducing vibration as described in the following sections. Metro incorporated the trackwork and vehicle construction and preventative maintenance measures into the vibration analysis assumptions about the location and magnitude of potential impacts.

TRACKWORK

During final Project design, Metro will incorporate LRT Build Alternative mitigation measures like resilient fasteners and resiliently supported rail ties. Resilient fasteners would fasten the rail to the primary support ties. Similarly, resiliency supported rail tie systems (such as ballast mats) would be used to separate and support rail ties from the ground. Both approaches would help dissipate vibration energy from the rail system before it enters the ground. This would minimize vibration and eliminate discontinuities in main rail sections (*e.g.*, rail sections without crossovers, changes, etc.).

VEHICLE CONSTRUCTION AND PREVENTATIVE MAINTENANCE

Wheel and rail interaction is the primary source of vibration in rail systems. The LRT Build Alternative would utilize all-new vehicles with wheels that are as close to perfectly round as is practical. A program of preventative maintenance, including rail grinding, rail head grinding, and wheel truing, would be implemented on the rail vehicles and tracks.

Rough wheels or rails can significantly increase vibration levels, potentially as much as 20 dB in extreme cases according to FTA's guidance manual. Over time, rail vehicle wheels can develop flat spots along the circumference of the wheel, which produce vibration. Over time, constant repetitive impact from rolling heavy-rail vehicles with flat spot wheels can cause corrugation of the steel rails. Effective maintenance of rail wheels, through service removal upon identification of audible wheel flat sounds and rail grinding, would avoid this condition. Specifically, preventative maintenance would keep both systems at "like-new" condition and significantly reduce vibration from the LRT Build Alternative.

HIGHLY SENSITIVE RESEARCH/EQUIPMENT – UB NORTH CAMPUS (IF APPLICABLE)

The vibration analysis did not find any predicted exceedances of the FTA's Category 1 (*i.e.*, High Sensitivity) vibration impact criteria at the UB North Campus buildings. However, these buildings contain vibration-sensitive equipment and activities that could not be accounted for by the FTA's generalized impact criteria. As such, it could be necessary to study potential vibration impacts further and implement measures to reduce vibration for equipment or areas particularly sensitive to vibration (*i.e.*, vibration at levels below the threshold of human perceptibility.)

A more detailed analysis of vibration would incorporate manufacturer-specific vibration criteria for sensitive equipment, exact details of building foundation and construction, geological conditions, and exact alignment location. A detailed vibration analysis would be necessary to identify the potential need for further vibration mitigation at sensitive locations and to specify the nature of such mitigation. Details will be outlined in a Memorandum of Agreement between

Metro and the State University of New York (SUNY). This agreement is expected to be included within the Final EIS.

As necessary, additional mitigation measures could include the following:

- Relocating potentially sensitive research or equipment to buildings that are farther from the final alignment of the LRT Build Alternative.
- Using specialized isolated construction or isolation tables for continued use of sensitive equipment and research in cases where relocation is not possible.
- Using specialized resilient bedding of track and rail utilizing floating slabs and resilient ballast bedding in the area adjacent to highly sensitive equipment/activities.

4.12.4.2 BRT Build Alternative

Based on the results of the general vibration assessment and expectation that vibration mitigation measures would be implemented for especially vibration-sensitive equipment as necessary, the BRT Build Alternative would not result in any adverse vibration or ground-borne noise impacts and would not warrant mitigation strategies.