Memorandum

To: Erica Quallen, VHB

Date: March 26, 2018

Project #: 57981.00

From: Mark Arnoldy, Air Quality and Noise Planner
Jason Ross, Director of Noise and Vibration

Re: Burlington Amtrak Storage Facility
Noise Analysis

The Chittenden County Regional Planning Commission (CCRPC), the City of Burlington (COB), the Vermont Agency of Transportation (VTrans), and Vermont Rail Systems (VRS), are collaborating on a study to identify an overnight storage and servicing location for the future Amtrak passenger train, in the greater Burlington area. A component of evaluating the feasibility of the five potential storage sites is the consideration of noise effects from idling locomotives at nearby sensitive locations including residences. This memorandum presents background information on noise, summarizes the assessment methodology, and presents results of the noise impact study.

Noise Background

Sound is the rapid fluctuations of air pressure above and below ambient pressure levels. Noise is defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, work, communication or recreation. How people perceive sound depends on several measurable physical characteristics including:

- **Sound Level** - Sound level is based on the amplitude change in pressure and is related to the loudness or intensity. Human hearing covers a wide range of changes in sound pressure amplitude. Therefore, sound levels are most often measured on a logarithmic scale of decibels (dB) relative to 20 micro-pascals. The decibel scale compresses the audible range of acoustic pressure levels, which can vary from the threshold of hearing (0 dB) to the threshold of pain (120 dB). Because sound levels are measured in dB, the addition of two sound levels is not linear. For example, adding two equal sound levels results in a 3 dB increase in the overall level. Research indicates the general relationships between sound level and human perception are as follows:
  - A 3-dB increase is a doubling of acoustic energy and is approximately the smallest difference in sound level that can be perceived in most environments.
  - A 10-dB increase is a tenfold increase in acoustic energy and is generally perceived as a doubling in loudness to the average person.
- **Frequency** - Sounds are comprised of acoustic energy distributed over a range of frequencies. Acoustic frequencies, commonly referred to as tone or pitch, are typically measured in Hertz. Human hearing generally ranges from 20 to 20,000 Hz; however, the human ear does not perceive sound levels from each frequency as equally loud. To compensate for this phenomenon in perception, a frequency filter known as A-weighting [dBA] is commonly used to evaluate environmental noise levels.
  - Sound levels reported in octave or one-third-octave frequency bands are often used to describe the frequency content of different sounds. Some sources of sound can generate "pure tones" which is when there is a concentration of sound within a narrow frequency range such as a whistle. Humans can hear pure tones very well and such conditions can be a cause of increased annoyance.

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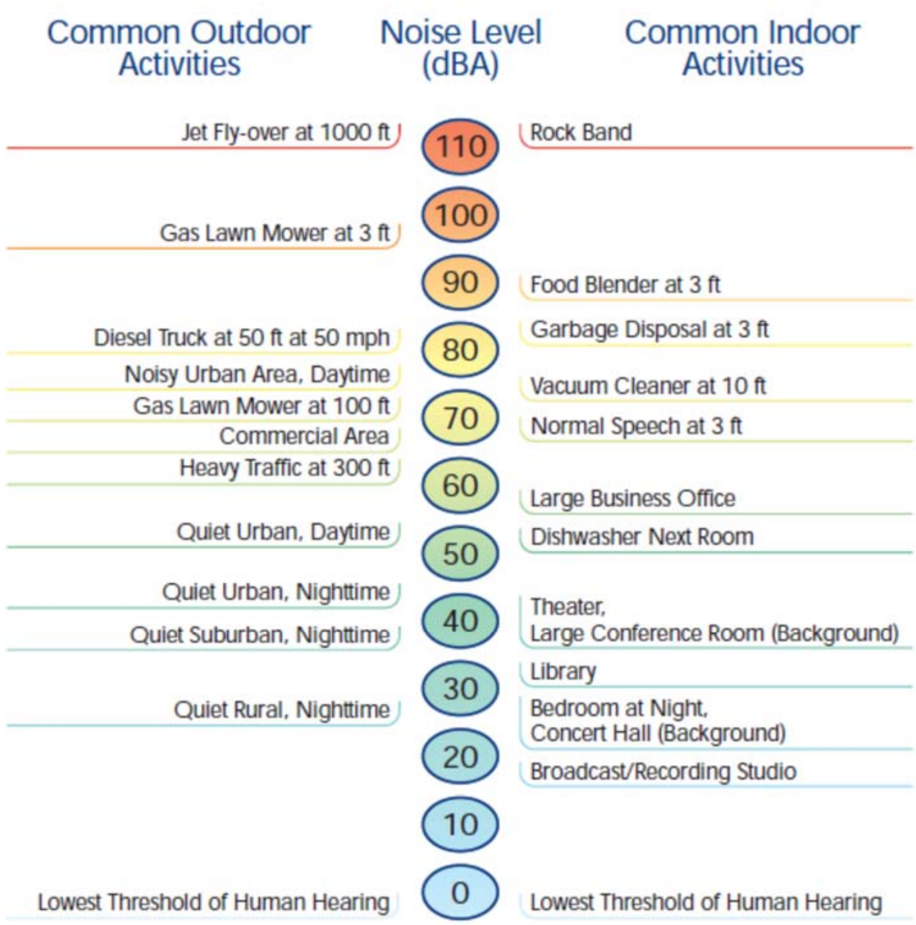
A variety of sound level descriptors can be used for environmental noise analyses. These descriptors relate to the way sound varies in level over time. The following is a list of common sound level descriptors:

- The *Maximum A-weighted Level* (Lmax) represents the highest sound level generated by a source. For mobile sources, the maximum level typically occurs when the source is closest to the measurement or analysis location.
- The *Energy-average Level* (Leq) is a single value that is equivalent in sound energy to the fluctuating levels over a period of time. The Leq accounts for how loud events are during the period, how long they last, and how many times they occur. Typically, Leq sound levels are used to describe the time-varying sound level over a 1-hour period and may be denoted as $Leq_{1h.}$ Leq is commonly used to describe environmental noise and relates well to human annoyance.

Figure 1 shows typical A-weighted sound levels for common outdoor and indoor activities.

- **Figure 1 Typical Ambient Outdoor and Indoor Sound Levels**



Source: Caltrans, 2016.

Regulatory Context

Noise generated by the proposed locomotive storage has been evaluated according to the Federal Railroad Administration (FRA) equipment regulations and Burlington Noise Ordinance.

FRA Equipment Regulations

The analysis of the potential storage sites considers idling noise generated by the head end power (HEP) of the diesel-electric locomotives. The HEP provides power to the rail cars without providing power to the traction motors. The FRA has equipment noise standards for all locomotives operating under stationary conditions with an idle throttle setting. As defined in 40 CFR 201.11, no locomotive manufactured after December 31, 1979 may exceed a maximum sound level of 70 dBA when operated at idle at a distance of 100 feet from the locomotive center. Since the Amtrak trains operate on a railroad subject to FRA jurisdiction, locomotives must comply with these idling noise standards.

Burlington Noise Ordinance

The City of Burlington has established a Noise Ordinance to preserve the public health, safety and welfare of its citizens. The purpose of the ordinance is to prohibit excessive and disturbing noise. The Burlington Noise Ordinance does not establish quantitative noise limits, but instead primarily focuses on restricting certain noise sources to specific times of day. The ordinance specifies express prohibitions on noise originating from parties, machinery, construction, loud speakers, radios, televisions and other sound amplification devices (including those in motor vehicles). A general prohibition is placed on any noise that disturbs, injures, or endangers the peace or health of any person or the community.

The Burlington Noise Ordinance does not prohibit noise generated from locomotives. Additionally, since noise from the locomotives is controlled by federal regulation, the local ordinance is not applied.

Analysis Methodology

Noise from the locomotives has been evaluated at each study location including nearby residential receptors.

Receptor Identification

Noise receptors were identified at all residential parcels experiencing sound levels 40 dBA and greater from the idling locomotives using a combination of available parcel data, aerial photography, and Google Street View™. Noise receptors were identified at single-family residences and multi-family residences and are tabulated according to the number of dwelling units. The number of residences that would be exposed to sound levels between 40 to 50 dBA, 50 to 60 dBA, and greater than 60 dBA.

Noise Sources

The noise analysis included one idling locomotive at each potential storage site. The reference sound level of the idling locomotive used in the study is provided in Table 1. The overall sound level of the reference emission is consistent with the maximum allowable sound level in FRA equipment regulations. The predominant noise source from the locomotive is the HEP exhaust which is assumed to be a point source 15 feet above the top of rail

Table 1 Locomotive Idling Emissions at 100 feet (dBA)

Source	Overall	Frequency (Hz)							
		63	125	250	500	1,000	2,000	4,000	8,000
Idling Locomotive	70	63	62	51	60	62	67	54	41

Source: "Background Document for Railroad Noise Emission Standards" *EPA*. EPA-550/9-76-005. December 1975.

Noise Model

Sound generated by the idling locomotive has been predicted using Cadna-A[1] sound prediction software which utilizes the methods outlined in the International Standards Organization (ISO) Standard 9613-2:2006[2]. This prediction method considers the topography, ground cover, wind conditions, and intervening objects such as buildings. The following summarizes the principal assumptions:

- Moderate downwind conditions are assumed which conservatively predict efficient sound propagation from the source to receptors in all directions.
- Sound attenuation is affected by shielding and diffraction provided by local buildings intervening the propagation path between the source and receptors.
- Ground cover in the study area is dependent on site specific conditions. The two sites close to the waterfront were assumed to include packed soil, gravel and pavement which provide acoustically hard ground. The three sites outside of the downtown area were assumed to include earth, grass, and other vegetation which provide acoustically soft ground.

Analysis Results

Sites 1 and 2 at the Urban Reserve are adjacent to residential neighborhoods with residences located approximately 200 feet from tracks. The neighborhoods are substantially elevated (~30 feet) above the proposed storage sites. This change in topography provides acoustic shielding from the idling locomotive. Nine residences at Site 1 and seven residences at Site 2 would experience maximum sound levels between 50 and 60 dBA. These receptors are located on the west side of Lakeview Terrace adjacent to the storage sites. Additional residences beyond this front row experience sound levels in the 40 to 50 decibel range with most residences in the third row experiencing sound levels less than 40 dBA.

Sites 3 and 4 are located at the Waterfront Station and the existing VRS Railyard. Both of these sites benefit from shielding provided by the dense building stock in the area. Few residential receptors are located immediately adjacent from the potential storage sites, with the exception of the Wing Building near Site 3. The four residential receptors at the Wing Building would experience sound levels between 70 and 80 dBA during locomotive idling at Waterfront Station. Only 6 residences would experience sound levels between 50 and 60 dBA at Waterfront Station and four residences would experience sound levels greater than 50 dBA at VRS Railyard. The Waterfront Station site has more

[1] Computer Aided Noise Abatement (Cadna-A). *DataKustik GmbH*. Version 2017. http://www.datakustik.com/en/products/cadnaa.
[2] "Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation" ISO 9613-2:2006. 2006.

residences with sound levels between 40 and 50 dBA as the idling locomotive noise travels relatively unimpeded by buildings down King Street to the residential neighborhood, as shown in Figure 4.

Site 5, Flynn Avenue, is located adjacent to multiple residential neighborhoods with relatively flat terrain and fewer intervening buildings than the other sites. These conditions allow for more efficient propagation of sound into the residential neighborhoods. Consequently, there would be a total of 138 residences exposed to sound levels between 40 and 50 dBA and 24 residences exposed to sound levels between 50 and 60 dBA.

The results of the noise modeling are presented in Table 2 and Figures 2 through 6. Table 2 presents the number of residences experiencing maximum (Lmax) sound levels between 40 and 50 dBA, between 50 and 60 dBA, between 60 and 70 dBA and greater than 70 dBA from the idling locomotive.

Table 2 Residential Receptors Exposed to Locomotive Sound

Site ID	Site Description	Number of Residences			
		40-50 dBA	50-60 dBA	60-70 dBA	70-80 dBA
1	Northern Urban Reserve	51	9	0	0
2	Southern Urban Reserve	20	7	0	0
3	Waterfront Station	24	6	0	4
4	VRS Railyard	11	4	0	0
5	Flynn Avenue	138	24	0	0

In summary, the VRS Railyard would affect the fewest number of residences with only four residences experiencing sound levels between 50 and 60 dBA. This site would likely also benefit from higher ambient sound levels at residences due to the denser neighborhood characteristics when compared to the other potential storage sites. Storage at the Flynn Avenue site would affect the greatest number residences due to the flat terrain and relative absence of intervening buildings.

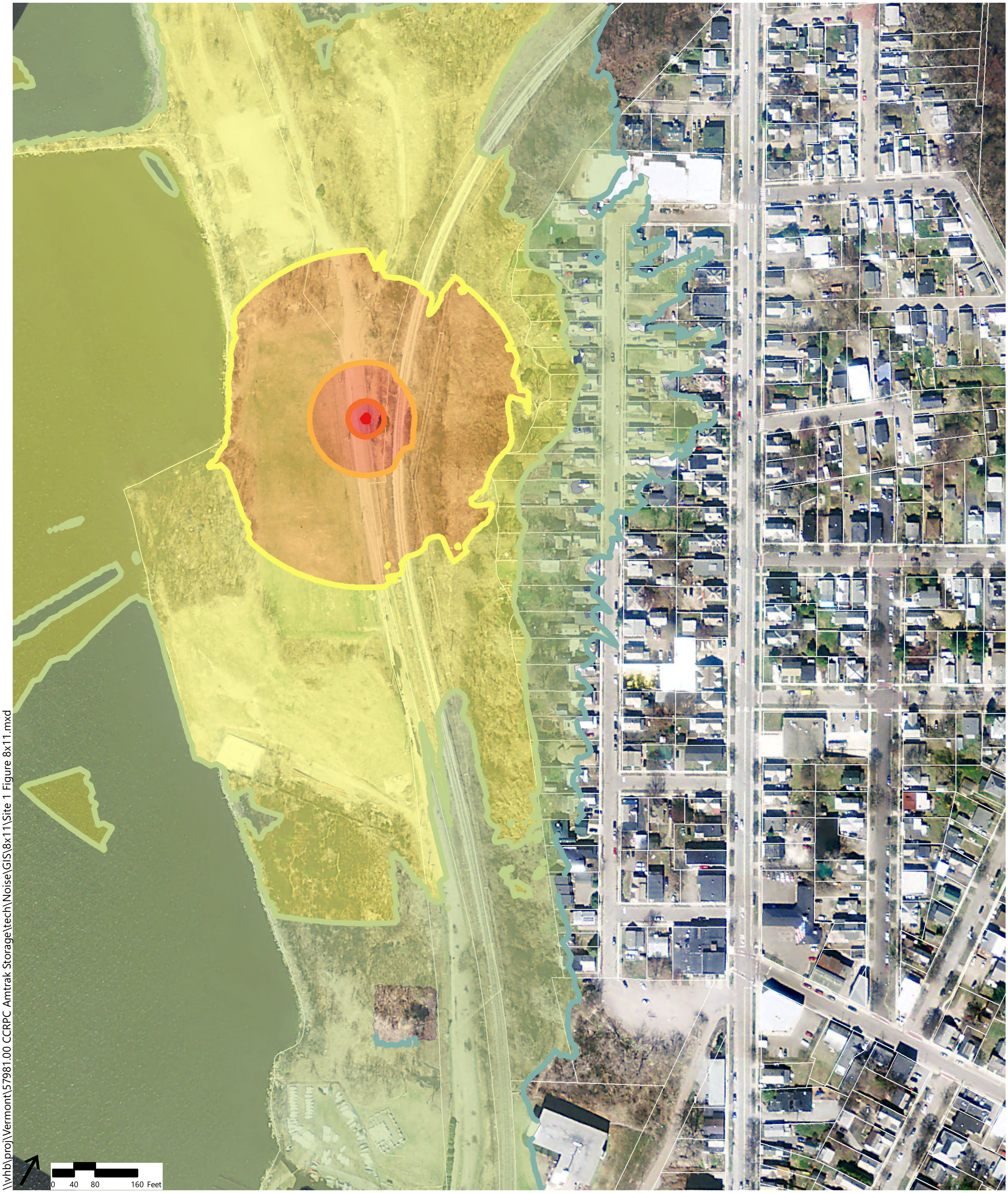


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Figure 2
Sound Level Contours
Northern Urban Reserve

Sound Levels

40-50 dBA	60-70 dBA	40 dBA
50-60 dBA	70-80 dBA	50 dBA
	>80 dBA	60 dBA
		70 dBA
		80 dBA
		90 dBA

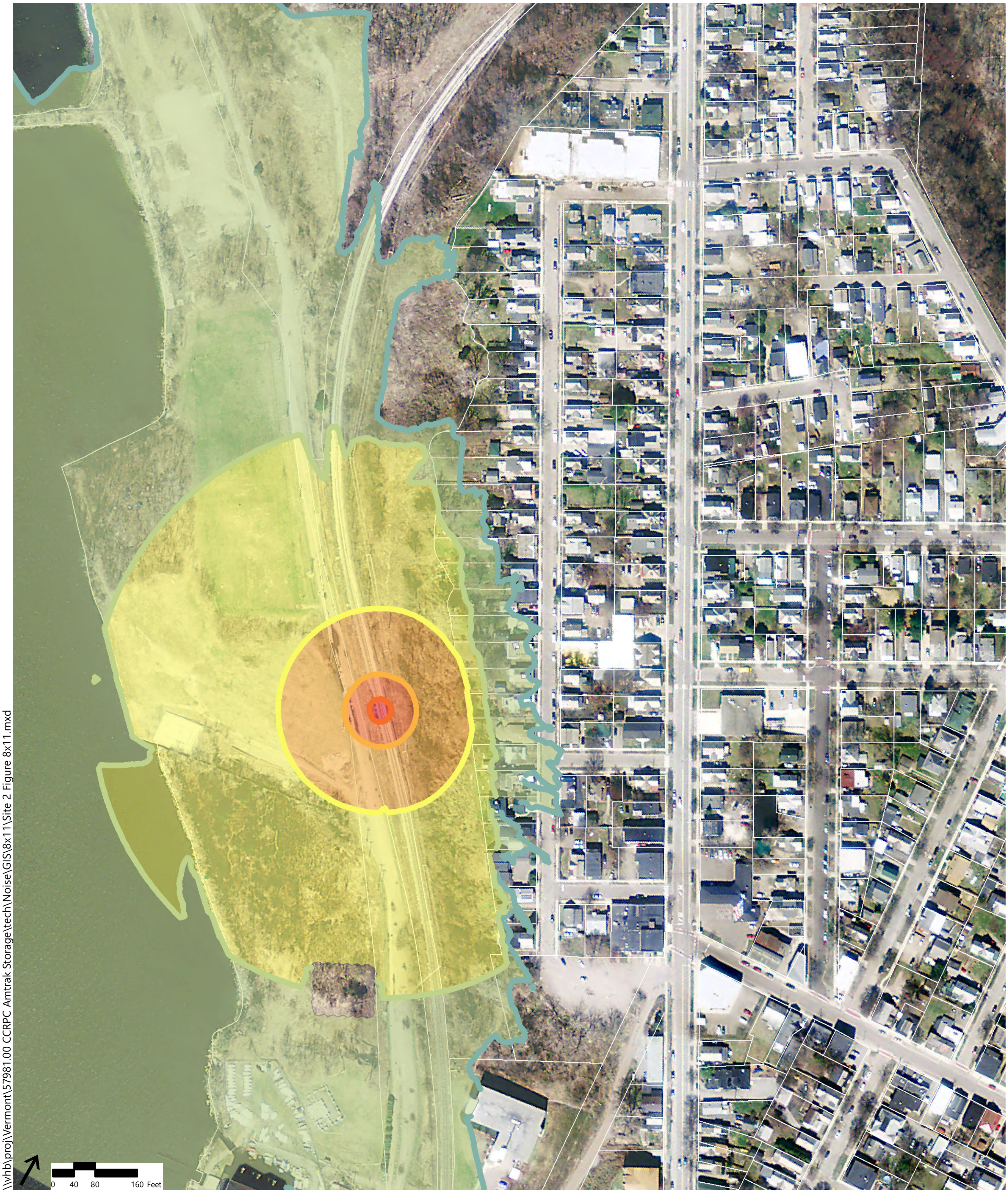

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Figure 3
Sound Level Contours
Southern Urban Reserve

Sound Levels

40-50 dBA
50-60 dBA
60-70 dBA
70-80 dBA
>80 dBA
40 dBA
50 dBA
60 dBA
70 dBA
80 dBA
90 dBA

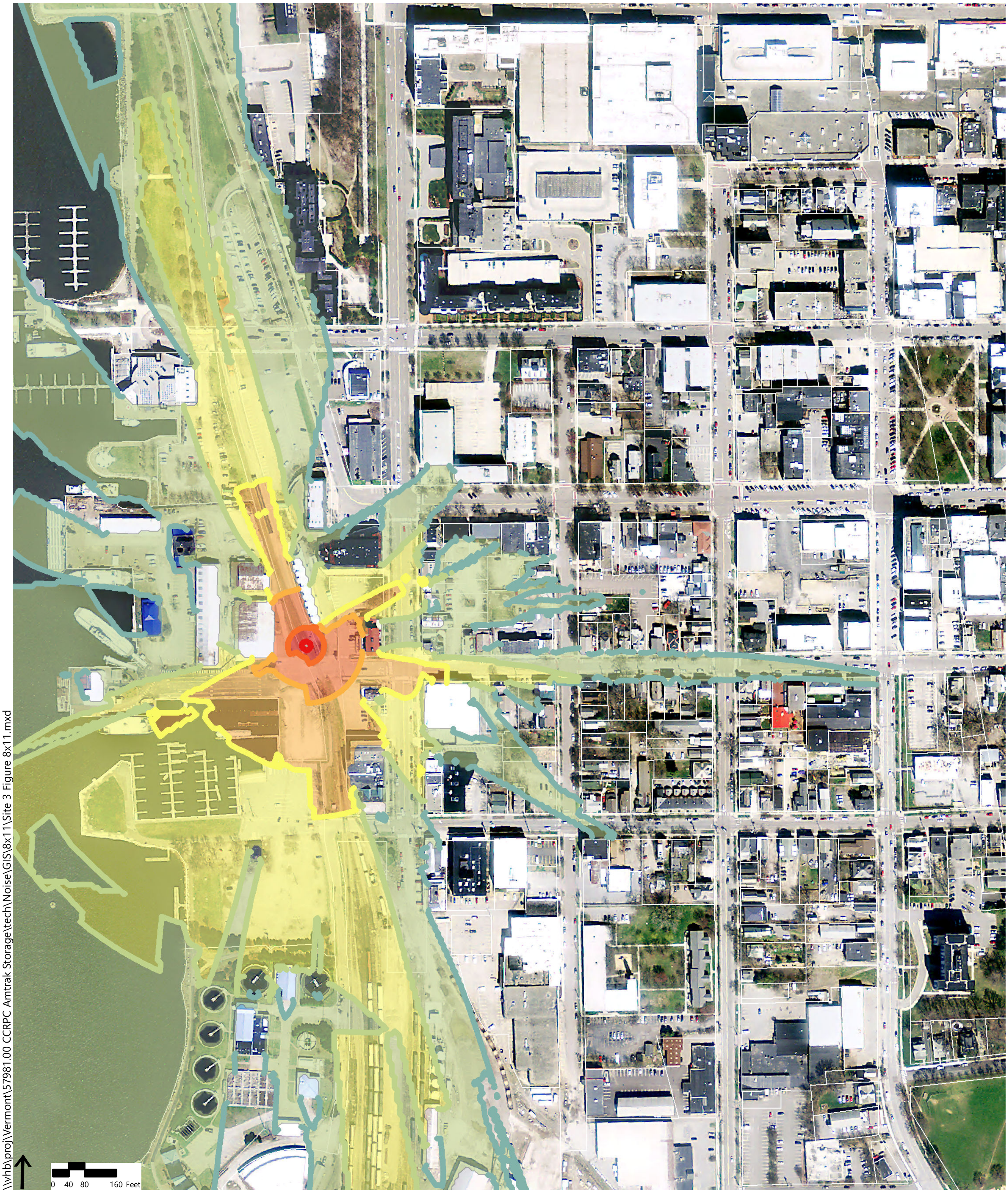

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Figure 4
Sound Level Contours
Waterfront Station

Sound Levels

- 40-50 dBA
- 50-60 dBA
- 60-70 dBA
- 70-80 dBA
- >80 dBA
- 40 dBA
- 50 dBA
- 60 dBA
- 70 dBA
- 80 dBA
- 90 dBA

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Figure 5
Sound Level Contours
VRS Railyard

Sound Levels

40-50 dBA
50-60 dBA
60-70 dBA
70-80 dBA
>80 dBA
40 dBA
50 dBA
60 dBA
70 dBA
80 dBA
90 dBA

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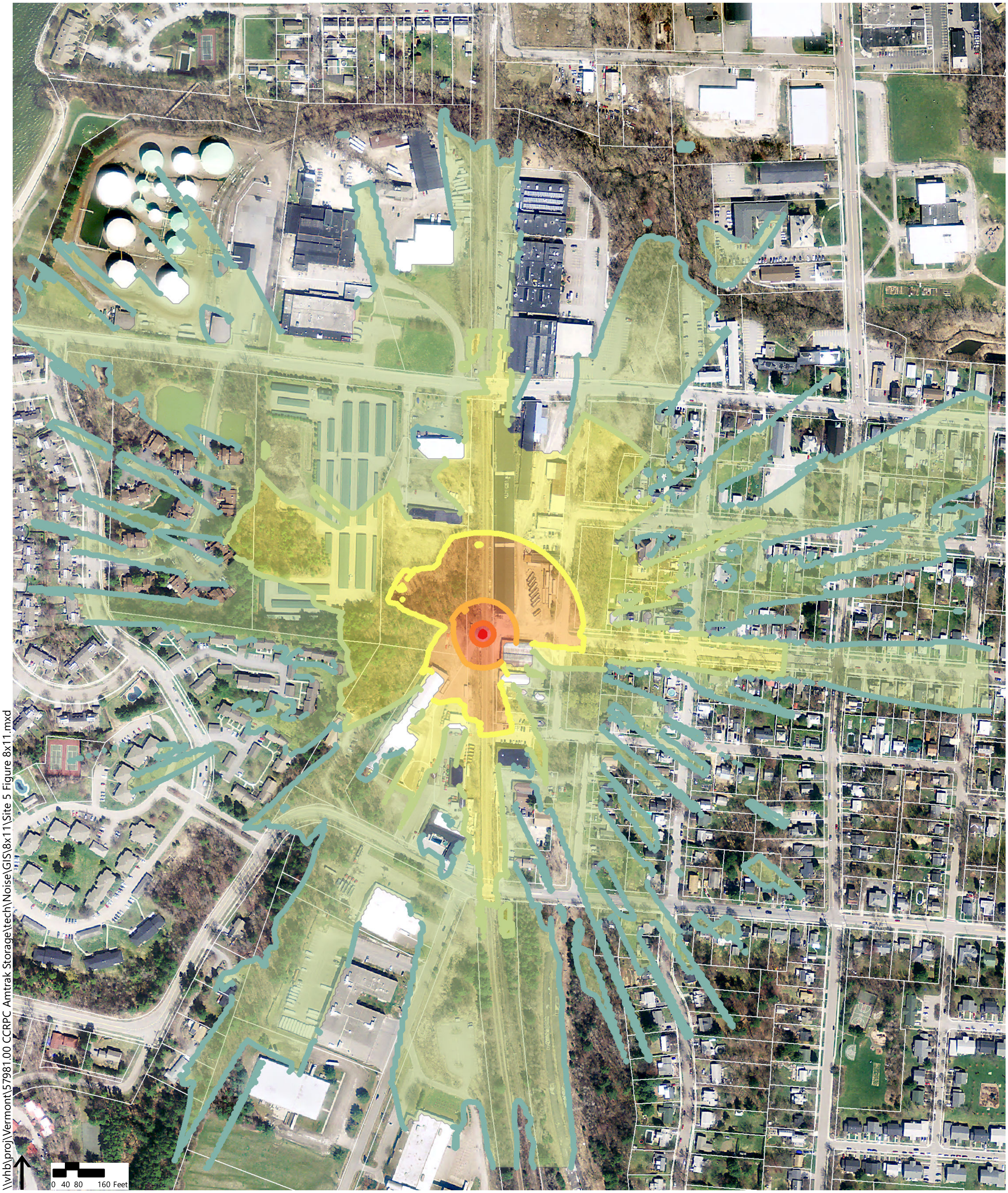

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Figure 6
Sound Level Contours
Flynn Avenue

Sound Levels

- 40-50 dBA
- 50-60 dBA
- 60-70 dBA
- 70-80 dBA
- >80 dBA
- 40 dBA
- 50 dBA
- 60 dBA
- 70 dBA
- 80 dBA
- 90 dBA