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NOISE MITIGATION REPORT

SSA ACOUSTICS (FEBRUARY 2, 2017)

Site Planning
Civil Engineering
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NOISE MITIGATION REPORT

Buckley Recycling Center
Enumclaw, WA

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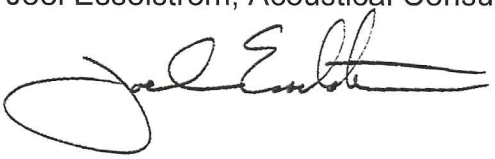
February 3, 2017

DOCUMENT INFORMATION

FILE NAME: Buckley Recycling Center

PROJECT #: 16-6412

PREPARED BY: Joel Esselstrom, Acoustical Consultant



REVIEWED BY: John Keiffer, Senior Consultant

DATE: February 3, 2017

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I. INTRODUCTION

This presents the Noise Mitigation report for the Buckley Recycling Center in Enumclaw, Washington. This is a follow up report the the Environmental Noise Impact Report that was previously sent to you on 1/18/2017. The initial noise impact report concluded that noise levels from the site will exceed the noise code limits at the adjacent property lines. A summary of this report is as follows:

1. The predicted noise levels are expected to have an impact on at the nearby residential receiver properties.

2. Phase 1 area noise levels from equipment exceed the daytime noise limits at the west and south property lines by approximately 4-5 dBA, which is considered a "slight impact" based on the ambient noise levels. Mitigation will be required.

3. Phase 2 area noise levels from equipment exceed the daytime noise limits at the east and south property lines by approximately 11-12 dBA, which is considered a "serious impact" based on the ambient noise levels. Mitigation will be required.

4. Phase 3 area noise levels from equipment exceed the daytime noise limits at the east property line by approximately 15 dBA, which is considered a "serious impact" based on the ambient noise levels. Mitigation will be required.

5. Phase 1 area noise levels from large heavy trucks meets the daytime noise limits at the west and south property lines. No mitigation will be required.

6. Phase 2 area noise levels from large heavy trucks exceeds the daytime noise limits at the south and east by approximately 2-4 dBA, which is considered a "slight impact" based on the ambient noise levels. Mitigation will be required.

7. Phase 3 area noise levels from large heavy trucks exceeds the daytime noise limits at the east property line by approximately 6 dBA, which is considered a "significant impact" based on the ambient noise levels. Mitigation will be required.

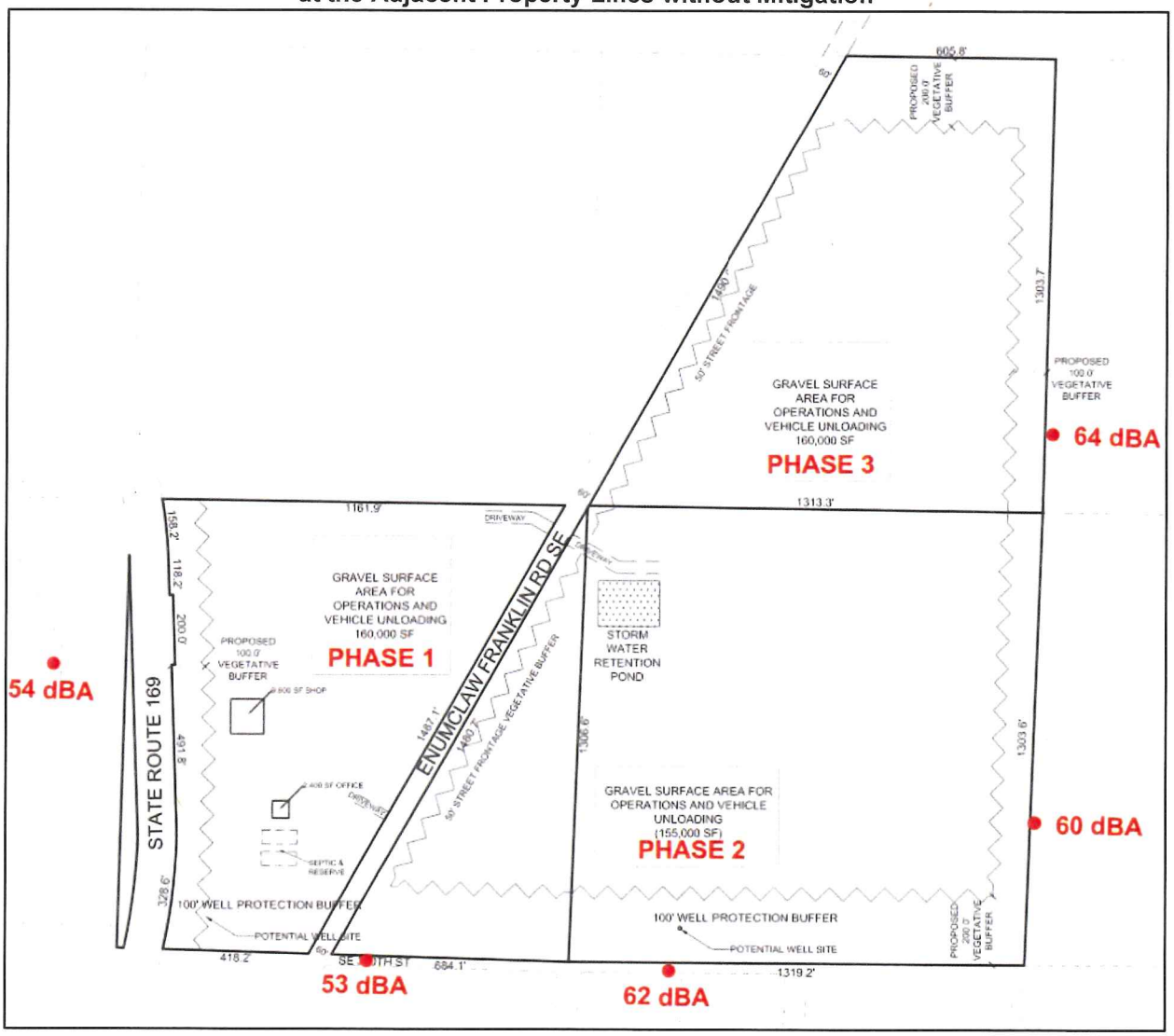
8. Truck drivers should be instructed to avoid slamming dump truck gates.

Please refer to the initial noise impact report for the noise measurements and predictions as they relate to the noise regulations. Furthermore, as this report contains many acoustical terms, please refer to the appendix for definitions and descriptors.

II. PREDICTED SOUND LEVELS AT PROPERTY

Based on measured noise levels of each proposed piece of equipment listed in our initial evaluation, we have calculated the noise impact on the adjacent property lines using the sum of all equipment noise levels. This represents the worst-case scenario for noise exposure in order to be conservative. Figure 1 below summarized the predicted noise levels at the receiving property lines.

Figure 1: Site Plan Showing Predicted Noise Levels at the Adjacent Property Lines without Mitigation

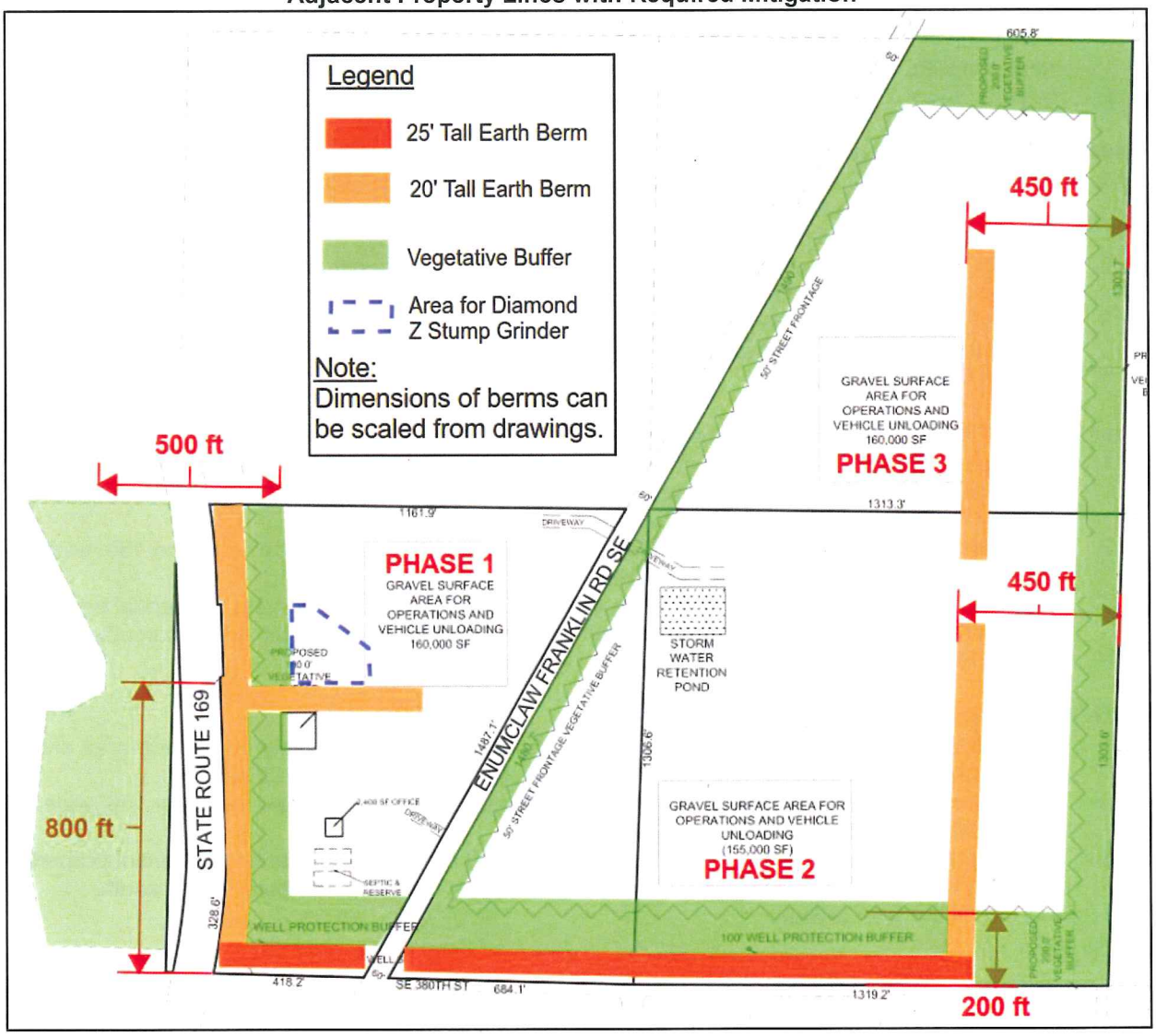


III. REQUIRED MITIGATION

A. Site Plan Showing Mitigation

Based on the noise levels in Figure 1, we have developed recommendations for reducing noise to these property lines. Figure 2 illustrates this mitigation.

Figure 2: Site Plan Showing Predicted Noise Levels at the Adjacent Property Lines with Required Mitigation



B. Noise Mitigation Design Notes

Phase 1 Area North Mitigation Recommendations:

1. Construct earth berms (shown in Figure 2) between the proposed equipment operation area and the residential neighborhood to the south and west. The berm shall be no less than 20' tall.
2. The phase 1 area North is the only area that shall hold the Diamond Z Stump grinder. It is important that is piece of equipment be positioned up against a berm on the west and south sides. It should not be stationed in the middle of an open area. Figure 2 above shows the recommended area for the stump grinder equipment to be positioned in a corner. This maximizes the noise blocking qualities of the earth berm.
3. The vegetation buffer shall be no less than 100 feet wide to the west and no less than 150' wide to the south of the equipment operation area.
4. The Stump Grinder equipment must be no less than 500 feet from the nearest residential property line to the west and no less than 800 feet from the nearest residential property to the south.
5. Refer to Figure 2 for layout.

Phase 1 Area South Mitigation Recommendations:

1. Construct earth berms (shown in Figure 2) between the proposed equipment operation area and the residential neighborhood to the south and west. The berm shall be no less than 20' tall to the west and no less than 25' tall to the south.
2. The vegetation buffer shall be no less than 100 feet wide to the west and no less than 150' wide to the south of the equipment operation area.
3. The equipment operation area must be no less than 500 feet from the nearest residential property line to the west and no less than 200 feet from the nearest residential property to the south.
4. Refer to Figure 2 for layout.

Phase 2 Area Mitigation Recommendations:

1. Construct earth berms (shown in Figure 2) between the proposed equipment operation area and the residential neighborhood to the south and east. The berm shall be no less than 20' tall to the east and no less than 25' tall to the south.
2. The vegetation buffer shall be no less than 100 feet wide to the east and no less than 150' wide to the south of the equipment operation area.
3. The equipment operation area must be no less than 450 feet from the nearest residential property line to the east and no less than 200 feet from the nearest residential property to the south.
4. Refer to Figure 2 for layout.

Phase 3 Area Mitigation Recommendations:

1. Construct earth berms (shown in Figure 2) between the proposed equipment operation area and the residential neighborhood to the east. The berm shall be no less than 20' tall.
2. The vegetation buffer shall be no less than 100 feet wide to the east and no less than 150' wide to the south of the equipment operation area.
3. The equipment operation area must be no less than 450 feet from the nearest residential property line to the east and no less than 200 feet from the nearest residential property to the south.
4. Refer to Figure 2 for layout.

IV. PREDICTED SOUND LEVELS AT PROPERTY LINES WITH REQUIRED MITIGATION

A. Equipment Noise Calculations:

Tables 1-4 show our calculated noise levels at the adjacent receiving property lines from each of the phased areas. Tables 1 and 2 are for phase 1 area, given that the phase 1 area is the only area divided into two areas. The area to the north is predicted to have noise levels as high as 95 dBA since all equipment can operate in this area. The phase 1 area to the south is predicted to have noise levels as high as 88 dBA, which is the sum of all equipment, excluding the stump grinder, as shown in Table 2. Tables 3 and 4 are for the other phased areas, which will not contain the stump grinder, and will therefore also use the predicted noise level of 88 dBA to calculate property line noise levels.

Table 1: Predicted Equipment Noise Levels at Nearest Property Lines from Phase 1 Area with Mitigation (All Equipment Including Stump Grinder)

Line	Application Factors (Phase 1 Area North)	South PL	West PL
1	Sum of all Equipment Noise Levels including the Stump Grinder(dBA).	95	95
2	Distance Factor (DF) for nearest property lines (dBA). Inverse-Square Law (Free Field): DF = 20*log (d1/d2)	-30 (800 ft)	-26 (500 ft)
3	Noise Attenuation from Earth Berm HARRIS (Acoustical Measurements and Noise Control, p. 3.19)	-10 (20' Tall)	-10 (20' Tall)
4	Attenuation from vegetation buffer (-3 dBA per 50 feet of dense vegetation)	-9 (150 ft)	-12 (200 ft)
5	New equipment Sound Pressure Level at receivers. (Add lines 1 – 4)	**46 dBA**	**47 dBA**

As shown in Table 1, the noise levels at the Phase 1 Area are are predicted to comply with the 49 dBA noise limit at the adjacent receiving properties with the required mitigation.

Table 2: Predicted Equipment Noise Levels at Nearest Property Lines from Phase 1 Area with Mitigation (Equipment Excluding Stump Grinder)

Line	Application Factors (Phase 1 Area South)	South PL	West PL
1	Sum of all Equipment Noise Levels Excluding the Stump Grinder(dBA).	88	88
2	Distance Factor (DF) for nearest property lines (dBA). Inverse-Square Law (Free Field): DF = 20*log (d1/d2)	-18 (200 ft)	-26 (500 ft)
3	Noise Attenuation from Earth Berm HARRIS (Acoustical Measurements and Noise Control, p. 3.19)	-13 (25' Tall)	-10 (20' Tall)
4	Attenuation from vegetation buffer (-3 dBA per 50 feet of dense vegetation)	-9 (150 ft)	-6 (100 ft)
5	New equipment Sound Pressure Level at receivers. (Add lines 1 – 4)	**48 dBA**	**46 dBA**

As shown in Table 2, the noise levels at the Phase 1 Area are are predicted to comply with the 49 dBA noise limit at the adjacent receiving properties with the required mitigation.

Table 3: Predicted Equipment Noise Levels at Nearest Property Lines from Phase 2 Area with Mitigation (Equipment Excluding Stump Grinder)

Line	Application Factors (Phase 2 Area)	South PL	East PL
1	Sum of all Equipment Noise Levels Excluding the Stump Grinder(dBA).	88	88
2	Distance Factor (DF) for nearest property lines (dBA). Inverse-Square Law (Free Field): DF = 20*log (d1/d2)	-18 (200 ft)	-25 (450 ft)
3	Noise Attenuation from Earth Berm HARRIS (Acoustical Measurements and Noise Control, p. 3.19)	-13 (25' Tall)	-10 (20' Tall)
4	Attenuation from vegetation buffer (-3 dBA per 50 feet of dense vegetation)	-9 (150 ft)	-6 (100 ft)
5	New equipment Sound Pressure Level at receivers. (Add lines 1 – 4)	**48 dBA**	**47 dBA**

As shown in Table 3, the noise levels at the Phase 2 Area are are predicted to comply with the 49 dBA noise limit at the adjacent receiving properties with the required mitigation.

Table 4: Predicted Equipment Noise Levels at Nearest Property Lines from Phase 3 Area with Mitigation (Equipment Excluding Stump Grinder)

Line	Application Factors (Phase 3 Area)	South PL	East PL
1	Sum of all Equipment Noise Levels Excluding the Stump Grinder(dBA).	88	88
2	Distance Factor (DF) for nearest property lines (dBA). Inverse-Square Law (Free Field): DF = 20*log (d1/d2)	-34 (1,300 ft)	-25 (450 ft)
3	Noise Attenuation from Earth Berm HARRIS (Acoustical Measurements and Noise Control, p. 3.19)	-7 (25' Tall)	-10 (20' Tall)
4	Attenuation from vegetation buffer (-3 dBA per 50 feet of dense vegetation)	-6 (100 ft)	-6 (100 ft)
5	New equipment Sound Pressure Level at receivers. (Add lines 1 – 4)	**41 dBA**	**47 dBA**

As shown in Table 4, the noise levels at the Phase 3 Area are are predicted to comply with the 49 dBA noise limit at the adjacent receiving properties with the required mitigation.

B. Large Truck Noise

Noise levels from heavy or large trucks are also expected to comply at property lines with the implementation of the earth berm and distance restrictions. No further mitigation will be needed specifically for these vehicles.

V. SUMMARY

This concludes our environmental noise impact mitigation recommendations for the Buckley Recycling Center project in Enumclaw, WA. Please review our recommendations and let us know if you would like to entertain other possibilities. These recommendations are designed to give you the most flexibility with your equipment within the phased area layouts we have designated for you.

It may appear that some of the recommended earth berms are overdesigned for noise reduction. We allowed for a factor of safety given that earth berms are less effective for reducing noise to property lines that are up hill from the BRC site, or to houses with second stories. For example, the properties to the east of the site are elevated on a hill. This provides some assurance where any unforeseen conditions may exist.

VI. APPENDIX: DESCRIPTORS

Sound is measured as a sound level in units of decibels (dB). Environmental sound as with most sound is measured as an A-weighted sound level (dBA). The A-weighting is a standard frequency weighting system based on the sensitivity of human hearing at various frequencies, particularly the greater sensitivity at mid and high frequency compared to lower frequencies.

People normally experience sound levels between 30 and 90 dBA. The lower level may be associated with a quiet bedroom or office and the higher value a loud vehicle, radio or power tool. Normal conversation has a noise level between 50 and 60 dBA.

Each 10 dB increase in sound level corresponds to a tenfold increase in sound energy but is judged by a listener as approximately a doubling of loudness. The smallest discernable changes in sound level are 2 to 3 dB. Changes of 5 dB are clearly noticeable.

Table 14

Change in Sound Level (dB)	Change in Apparent Loudness
1	Imperceptible (except for tones)
3	Just barely perceptible
5	Clearly noticeable
10	About twice (or half) as loud
20	About 4 times (or one-forth) as loud

Sound levels from two or more sources are combined using logarithmic addition, not by directly adding the levels. When two levels are combined, the louder level dominates. For instance, when 50 dBA is combined with 50 dBA the result is 53 dBA. However, when 50 dBA is combined with 40 dBA the result is 50.4 dBA, a negligible difference in terms of environmental noise.

Normally, sound levels increase the closer the receiver is to the noise source. The amount of sound level reduction with distance can be predicted based on the physical dimensions of the source and the distance to the listener. For small sources, sound levels decrease by 6 dB for every doubling of distance. For instance, if the sound level 50 feet from a source is 60 dBA, the sound level 100 feet from the source will be approximately 54 dBA.

Other factors may affect the sound level from a source at a particular listener including the presence of hills, berms and other barriers, and trees and ground foliage located between the source and listener.

Because sound fluctuates over time, several A-weighted sound level descriptors are used to characterize the sound. In this report, the following descriptors are used:

Decibel
A basic metric for describing the amplitude of sound. A division of a uniform scale based on 10 times the logarithm to the base 10 of the relative value being compared to a reference value.

A-Weighting Decibel (dBA)
The A-weighting system is a specific filter that corresponds to the frequency response of the human ear.

Equivalent Sound Level (Leq)
This is the most commonly used descriptor for measuring fluctuating sound. The Leq is the level of a constant sound that over a given time period contains the same amount of sound energy as the measured fluctuating sound event. The Leq is typically used as an approximation to the average sound level for the purpose of code compliance.