Memorandum

DATE: *July 12, 2023*

TO: *Steven Dahl – Skagit Aggregates, LLC*

FROM: *Drew Savas, INCE*

RE: *Skagit Aggregates Rockport Crushing Plant – Noise and Vibration Code Compliance Report*

INTRODUCTION

The intent of this memorandum is to present predicted sound and vibration levels from anticipated mining, crushing and reclamation operations, compare predicted sound levels with regulatory criteria, and recommend mitigation for Skagit Aggregates' Rockport Crushing Plant (Site) at 50796 Cascade Highway 20, in Skagit County, Washington.

SUMMARY

Predicted sound levels from mining, crushing and reclamation operations comply with Skagit County Code environmental sound level limits, if the property north of the Site is considered Class C and the noise mitigation discussed in this report is implemented. The crushing plant is not anticipated to operate during nighttime hours and therefore, is not required to meet nighttime environmental sound level limits at residential-use properties.

Vibration criterion was developed for the Site to satisfy the vibration regulations in the Skagit County Code. Vibration produced by the Site is anticipated to comply with the vibration criterion and satisfy code requirements.

NOMENCLATURE

Decibel, dBA

The auditory response to sound is a complex process that occurs over a wide range of frequencies and intensities. Decibel levels, or "dB," are a form of shorthand that compresses this broad range of intensities with a convenient numerical scale. The decibel scale is logarithmic. For example, using the decibel scale, a doubling or halving of energy causes the sound level to change by 3 dB; it does not double or halve the sound loudness as might be expected.

The minimum sound level variation perceptible to a human observer is generally around 3 dB. A 5-dB change is clearly perceptible, and an 8 to 10 dB change is associated with a perceived doubling or halving of loudness. The human ear has a unique response to sound pressure. It is less sensitive to those sounds falling outside the speech frequency range. Sound level meters and monitors utilize a filtering system to approximate human perception of sound. Measurements made utilizing this filtering system are referred to as "A weighted" and are called "dBA".

Table 1. A-weighted Levels of Common Sounds

Sound	Sound Level (dBA)	Approximate Relative Loudness[A]
Jet Plane at 100 feet	130	128
Rock Music with Amplifier	120	64
Thunder, Danger of Permanent Hearing Loss	110	32
Boiler Shop, Power Mower	100	16
Orchestral Crescendo at 25 feet	90	8
Busy Street	80	4
Interior of Department Store	70	2
Ordinary Conversation at 3 feet	60	1
Quiet Car at Low Speed	50	1/2
Average Office	40	1/4
City Residence, Interior	30	1/8
Quiet Country Residence, Interior	20	1/16
Rustle of Leaves	10	1/32
Threshold of Hearing	0	1/64

[A] As compared to ordinary conversation at 3 feet.

Source: US Department of Housing and Urban Development, Aircraft Noise Impact Planning Guidelines for Local Agencies, November 1972.

Sound Pressure Level, SPL

Sound pressure level correlates with what is heard by the human ear. SPL is defined as the squared ratio of the sound pressure with reference to 20 μPa. Sound pressure is affected by distance, path, barriers, directivity, etc.

Equivalent Sound Level, L_{EQ}

L_{EQ} is the A-weighted level of a constant sound having the same energy content as the actual time-varying level during a specified interval. The L_{EQ} is used to characterize complex, fluctuating sound levels with a single number. Typical intervals for L_{EQ} are hourly, daily, and annually.

Percentage Sound Level, $L_{(n)}$

$L_{(n)}$ is the sound level that is exceeded n percent of the time; for example, L_{08} is the level exceeded 8% of the time. L_{25} is the sound level exceeded 25% of the time.

Maximum Sound Level, L_{MAX}

L_{MAX} is the maximum recorded root mean square (rms) A-weighted sound level for a given time interval or event. L_{MAX} "fast" is defined as a 125-millisecond time-weighted maximum, while L_{MAX} "slow" corresponds to a 1-second time-weighted maximum. All L_{MAX} values in this report are L_{MAX} fast.

Sound Power Level, PWL or L_WA (A-weighted PWL)

Sound power is the amount of energy per second generated by a source, measured in watts. The sound power level (PWL) is a decibel representation with a reference value of 1 pico-watt (pW). Sound power is independent of distance, path, or influence from any nearby surfaces.

Vibration

Vibration is an oscillatory motion, which can be measured in a variety of ways: displacement, velocity or acceleration. The displacement is a measure of the distance that a point moves away from its resting position. The velocity represents the instantaneous speed of the movement, and acceleration is the rate of change of the speed.

Peak Particle Velocity, PPV

Peak Particle Velocity describes the maximum instantaneous vibration velocity of a measurement surface within a specified time period, in a given direction. The value is expressed in inches-per-second (in/sec).

NOISE REGULATORY CRITERIA

The proposed crushing plant and all nearby properties are within unincorporated Skagit County. Therefore, the Skagit County Code will govern sound emissions from the site.

Skagit County Code

Chapter 9.50 Noise Control and Chapter 14.16.840(5) Performance Standards of the Skagit County Code (Code) adopts section 173-60 Maximum Environmental Noise Levels from the Washington Administrative Code (WAC). WAC and the Code, group multiple land use or zoning designations into three noise districts called Environmental Designations for Noise Abatement (EDNA). Chapter 14.16.840(5) of the Code defines EDNAs as:

- Class A EDNA: Residential Use Zones (RI, RVR, RRv, R, URR)
- Class B EDNA: Commercial Zones (RVC, RC, RFS, SRT, SSB, RB, BR-LI, AVR, URC-I), Public Use Zones OSRSI and URP-OS
- Class C EDNA: Industrial Zones (NRI, RMI, BR-HI), Forestry Zones (IF-NRL, SF-NRL, RRc-NRL), Agricultural Zone (Ag-NRL)

Maximum permissible environmental sound levels are defined by Chapter 9.50.040(1) of the Code which adopts WAC Section 173-60-040. These sound level limits are based on the EDNA the sound source originates within (EDNA of Sound Source) and the EDNA where the sound is received (EDNA of Receiving Property). A summary of the applicable sound level limits can be found in Table 2.

Table 2. Maximum Permissible Environmental Noise Levels, L_{25}

EDNA of Sound Source	EDNA of Receiving Property		
	Class A	**Class B**	**Class C**
Class A	55 dBA	57 dBA	60 dBA
Class B	57 dBA	60 dBA	65 dBA
Class C	**60 dBA**	65 dBA	**70 dBA**

Source: Chapter 9.50.040(1) Skagit County Code, Section 173-60-040 Washington Administrative Code

At any hour of the day or night the applicable noise limitations may be exceeded at any receiving property by no more than:

- 5 dBA for a total of 15 minutes in any one-hour period; or
- 10 dBA for a total of 5 minutes in any one-hour period; or
- 15 dBA for a total of 1.5 minutes in any one-hour period.

While WAC 173-60 does not establish noise metrics for these sound level limits, the base limit for the Site (60 or 70 dBA) is commonly interpreted as an L_{25} statistical sound level. Where it is not feasible to predict L_{25} sound levels during design, an hourly L_{EQ} is often used as a substitute metric to predict L_{25} compliance. Regulated sound emissions from the Site can never exceed 75 dBA at Class A properties and 85 dBA at Class C properties, which is applied as an L_{MAX} metric.

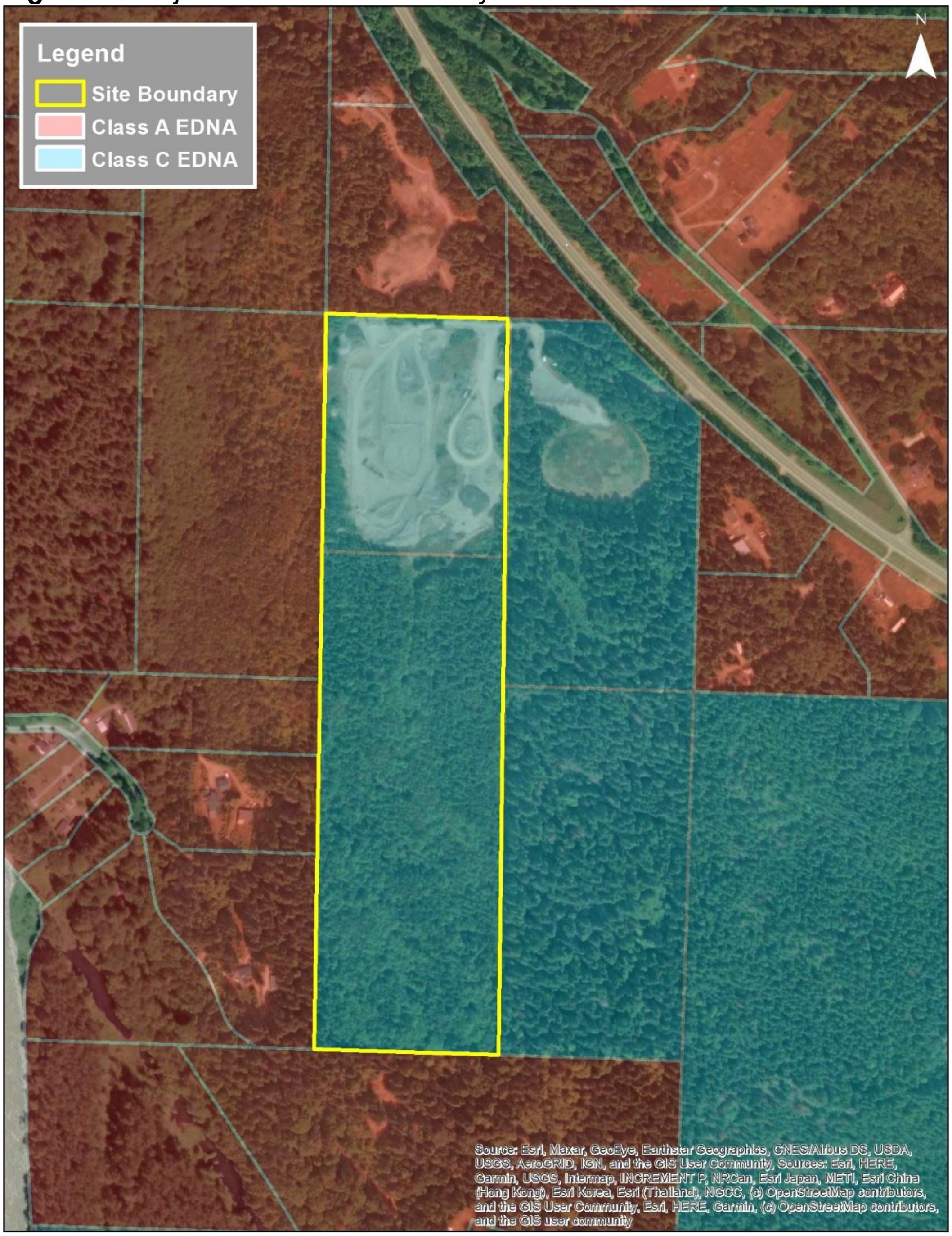
Modifications to the environmental sound level limits set forth in Table 2 are also outlined in Section 173-60-040 of the WAC. These modifications are for certain times of day and classification of receiving properties. These modifications to the environmental sound level limits include a 10 dBA reduction during the nighttime hours of 10 p.m. to 7 a.m. when the receiving property is within Class A EDNAs.

Noise originating from haul trucks is exempt when they are operating on a public highway. Backup alarms are interpreted to be exempt. Forest harvesting is exempt except at Class A properties during nighttime hours.

The Site is a Class C EDNA, and nearby properties are a mix of Class A and Class C. Sounds from the Site will be limited to 60 dBA L_{25} at Class A properties during daytime and 70 dBA L_{25} at Class C properties during daytime hours.

The Site and adjacent parcels east of the Site are Class C EDNA due to being zoned Rural Resource – Natural Resource Lands (RRc-NRL). All other adjacent parcels are Class A EDNA due to being zoned Rural Reserve (RRv). Figure 1 provides a graphical representation of EDNAs near the proposed crushing plant**.**

Figure 1. Project Location and Nearby EDNAs



Source: Skagit County GIS.

The parcel north of the Site, which is later introduced as Parcel 17, is zoned as Rural Reserve (RRv) which falls under Class A EDNA. At the time of this report, this parcel was owned by WSDOT and used as a gravel pit, which is inconsistent with the noise sensitivity typically associated with Class A properties. This analysis treats the parcel north of the Site as a Class C EDNA even though it falls under Class A due to its zoning.

ACOUSTICAL MODEL

The primary tool used for the sound level analysis and prediction was the 3-D computer noise modeling software environment, Cadna/A. Cadna/A utilizes the CADNA (Control of Accuracy and Debugging for Numerical Applications) computation engine developed by the Pierre et Marie Curie University of Paris. The model used for this project utilized the International Organization for Standardization 9613 Part II algorithms, implemented in the Cadna/A software, which accounted for the effects of distance, topography, and surface reflections on sound levels predicted for modeled activities. The acoustical model is typically accurate to within 3 dB. Some conservative assumptions were used in the model created for this project to ensure sufficient design margin within the predicted sound levels. Therefore, predicted sound levels can be compared to applicable criteria directly, without consideration of additional design margin.

The future topography of the site was determined from drawings and information provided by Skagit Aggregates, LLC and Jepson & Associates. Existing topography, property lines, and land uses were determined from Skagit County Geographic Information System (GIS) records and Google Maps. Sound power levels for the equipment or activities are shown in Table 3 and were determined through measurements of similar equipment at other mines or were provided by the manufacturers. Sound levels for crushing equipment will depend on the type of material being crushed, therefore a 3 dB safety margin was included for the crushing equipment. The sound power levels in Table 3 do not include backup alarms as they are considered exempt. It is recommended that all equipment be fitted with broadband, or ambient sensing broadband backup alarm if safety requirements can be met.

Table 3. Equipment Sound Power Levels, L_WA

Equipment	Activity	Sound Power Level	
		L_{EQ}	L_{MAX}
Caterpillar 980G Loader	Loader working; moving material and scraping	110	122
	Loading Dump Trucks; includes truck idle	110	122
Terex Finlay J-1160 Jaw Crusher	Crushing	119	-
Terex Finlay C-1540 Cone Crusher	Crushing	114	-
Caterpillar 336E Excavator	Excavator working; excavation, moving, and compacting material	107	-
Haul Trucks	Unloaded; speed approximately 15 mph, without Jacob brakes	105	-
	Loaded; speed approximately 10 mph, without Jacob brakes	100	-
Caterpillar D9R Dozer	Moving material and leveling ground	107	-

Note: Sound power levels calculated from sound pressure measurements, except for Terex Finlay equipment, which was provided by the manufacturer.

Mining and crushing operations will occur primarily in the Site's southern parcel. Mining and crushing operations are expected to advance south, in 10 acre segments. Reclamation will occur in the extracted 10 acre segment once mining and crushing operations have advanced to the next 10 acre segment. The crushing plant will operate between the daytime hours of 7 a.m. and 6 p.m. Therefore, the nighttime 10 dB reduction in sound level limits at Class A EDNAs will not apply. Anticipated operations over the lifetime of the Site were modeled using three phases, which are summarized in Table 4.

Table 4. Acoustical Model Scenarios

Scenario	Activities and Location
Phase 1	Mining and crushing operations will occur in the northern 10 acre segment of the Site's southern parcel. Reclamation will occur in the Site's northern parcel.
Phase 2	Mining and crushing operations will advance 10 acres south in the Site's southern parcel. Reclamation will occur in the 10 acre segment that was mined in Phase 1.
Phase 3	Mining and crushing operations advance to remaining unmined area in the Site's southern parcel. Reclamation will occur in the 10 acre segment that was mined in Phase 2.

Equipment associated with mining is quite mobile and therefore not all combinations of equipment locations can be captured by the acoustic model. To ensure modeling represents events and periods when sound limits are most likely to be exceeded, equipment was placed in the acoustic model at their expected locations when sound levels will be the greatest at adjacent Class A properties. Equipment locations for the model scenarios in Table 4 can be found in the appendix.

NOISE ANALYSIS AND MITIGATION

Locations of the modeled equipment and model parameters can be found in Appendix B. Predicted sound level contours for each model scenario are found in this section. Sound level contours are similar to elevation contours where one line represents a single elevation, except that the line represents a single sound level. Sound levels between two sound level contours can be approximated. Predicted sound levels do not include ambient, future, or any sound sources not included in Table 3.

Phase 1

Phase 1 is anticipated to consist of mining, crushing, and reclamation. Mining will occur in the northern 10 acres of the Site's southern parcel. The crushing machines will advance south and will be located at the base of the embankment created by extraction. The crushing machines will be located as close to the western and southern embankments as Skagit Aggregates determines to be safe. Locating the crushing machines as far west and south as possible will utilize the embankments created naturally during mining as noise mitigation for the Class A properties to the west of the Site.

Mining and crushing will utilize a jaw and cone crusher, loader, excavator, and a dozer. The loader and dozer will travel throughout the 10 acres being mined. The dozer is operating near the Site's western property line in the acoustical model to represent a worst-case condition for the Class A properties west of the Site. The excavator is anticipated to remain near the crushing operation. Haul trucks will enter at the northeast corner of the Site and will travel west, along the northern property line before turning south to travel to the crushing operation. The haul route will be similar during subsequent phases. A peak hourly volume of 5 trucks per hour was used for the acoustical analysis. Reclamation during Phase 1 will occur in the Site's northern parcel and will utilize a loader.

It was found that sound originating from crushing would cause sound limit exceedances north of the crushing machines. Therefore, a noise berm will need to be constructed north of the crushing operation. This noise berm should be tall enough that the crushing machines are not visible when standing along the western and northern property line.

Figure 2 shows predicted sound level contours for Phase 1 activities with the proposed noise berm.

Phase 2

Phase 2 is anticipated to consist of mining, crushing, and reclamation. Mining will occur in the 10 acre segment directly south of the area that will be mined during Phase 1. Equipment used during Phase 2 is anticipated to be the same as during Phase 1. As mining advances in Phase 2, an area along the western property line that has an existing elevation that is the same as the final pit floor elevation will be exposed. This will cause the sound limits to be exceeded because there will not be an embankment to reduce sound levels from mining and crushing from reaching the neighboring property. Therefore, the noise mitigation strategy used during Phase 1 of placing crushing machines as far south and west as possible will only be effective until mining advances to this area where the existing elevation is lower. When mining reaches this lower elevation area, the crushing machines will need to be moved as far east and south as Skagit Aggregates determines to be safe, and a noise berm will need to be constructed on the west side of the crushing machines so that they are not visible from the western property line. With this mitigation in place, sound levels from the Site are predicted to comply with sound limits, as shown in Figure 3.

Phase 3

Phase 3 activities and equipment are anticipated to be similar to Phases 1 and 2 with mining and crushing advancing into the remaining area of the Site's southern parcel. Reclamation is anticipated to occur in the area mined during Phase 2. Mining and crushing during the beginning of Phase 3 will still be in the vicinity of the Phase 2 lower elevation area discussed in the previous section. The Phase 2 noise mitigation strategy of placing the crushing operation as far south and east as Skagit Aggregates determines to be safe, and behind a noise berm should remain in place until extraction has advanced well past this lower elevation area. Once mining has advanced sufficiently past this lower elevation, the Phase 1 mitigation strategy of placing the crushing machines as far south and west as Skagit Aggregates determines to be safe, and behind a noise berm north of the machines should be reinstated. Following these mitigation strategies during Phase 3 results in predicted sound levels complying with sound limits, as shown in Figure 4.

Figure 2. Predicted Sound Level Contours – Phase 1, L_{EQ}(Hr)

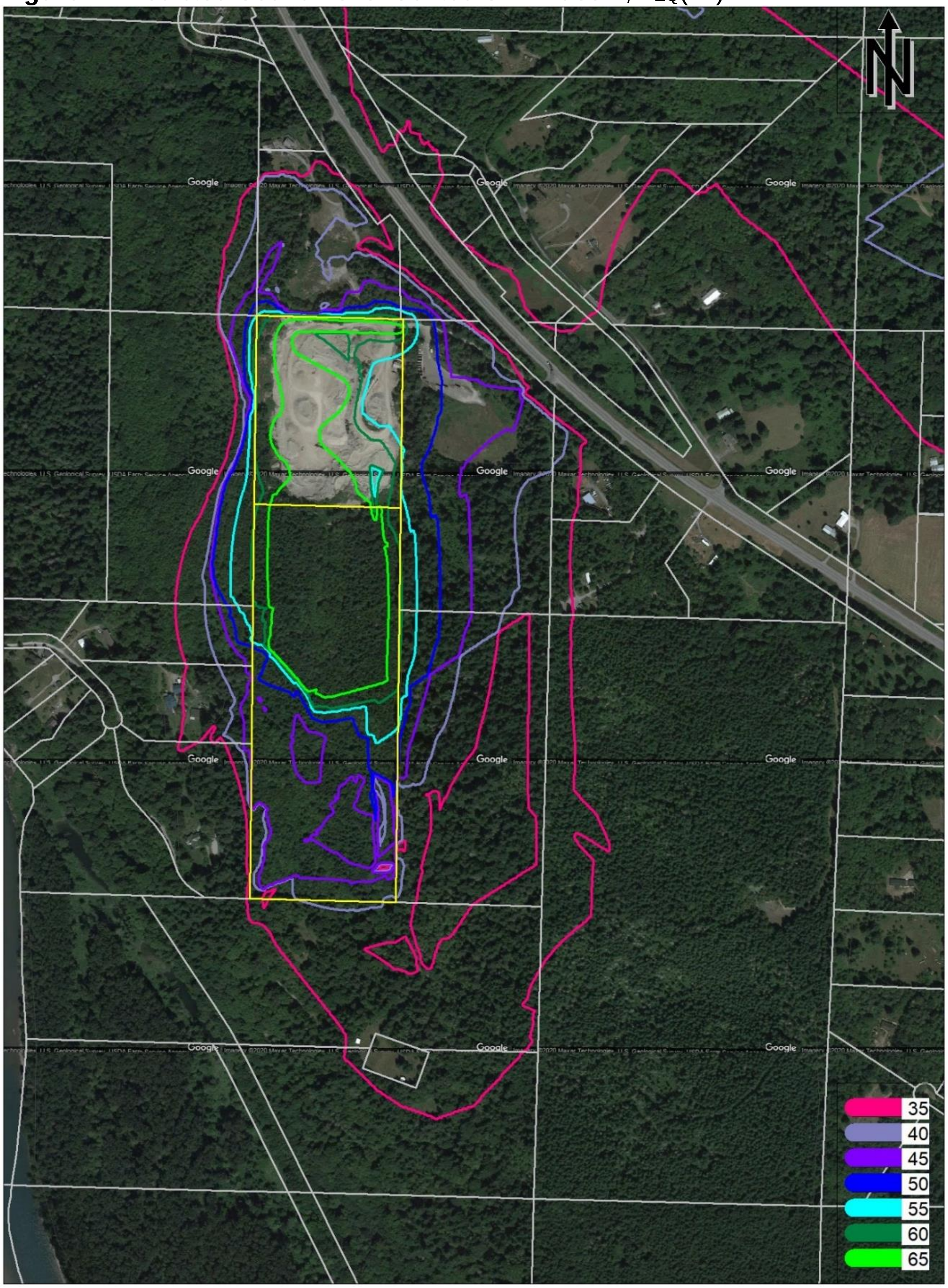


Figure 3. Predicted Sound Level Contours – Phase 2, L_{EQ}(Hr)

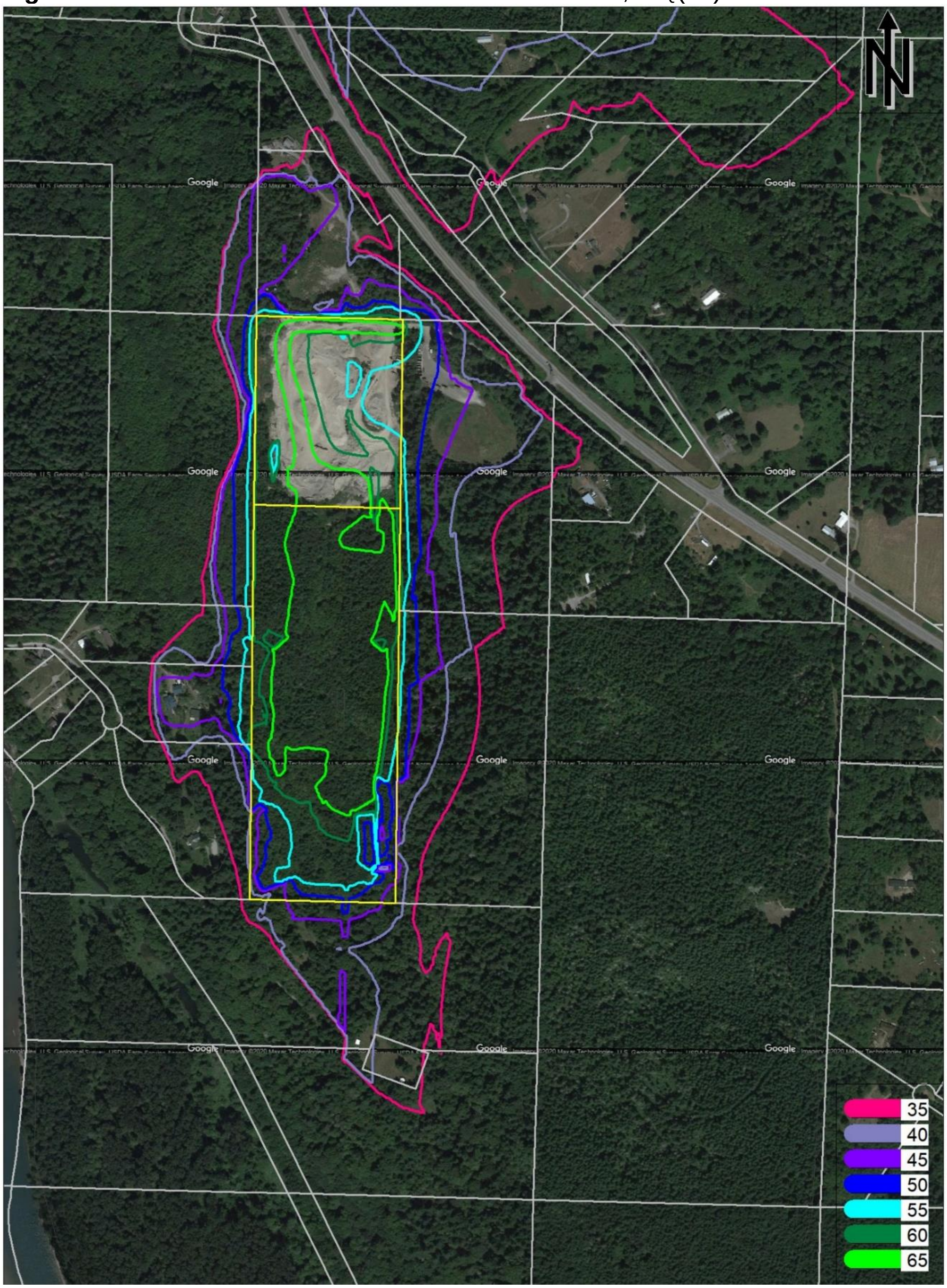
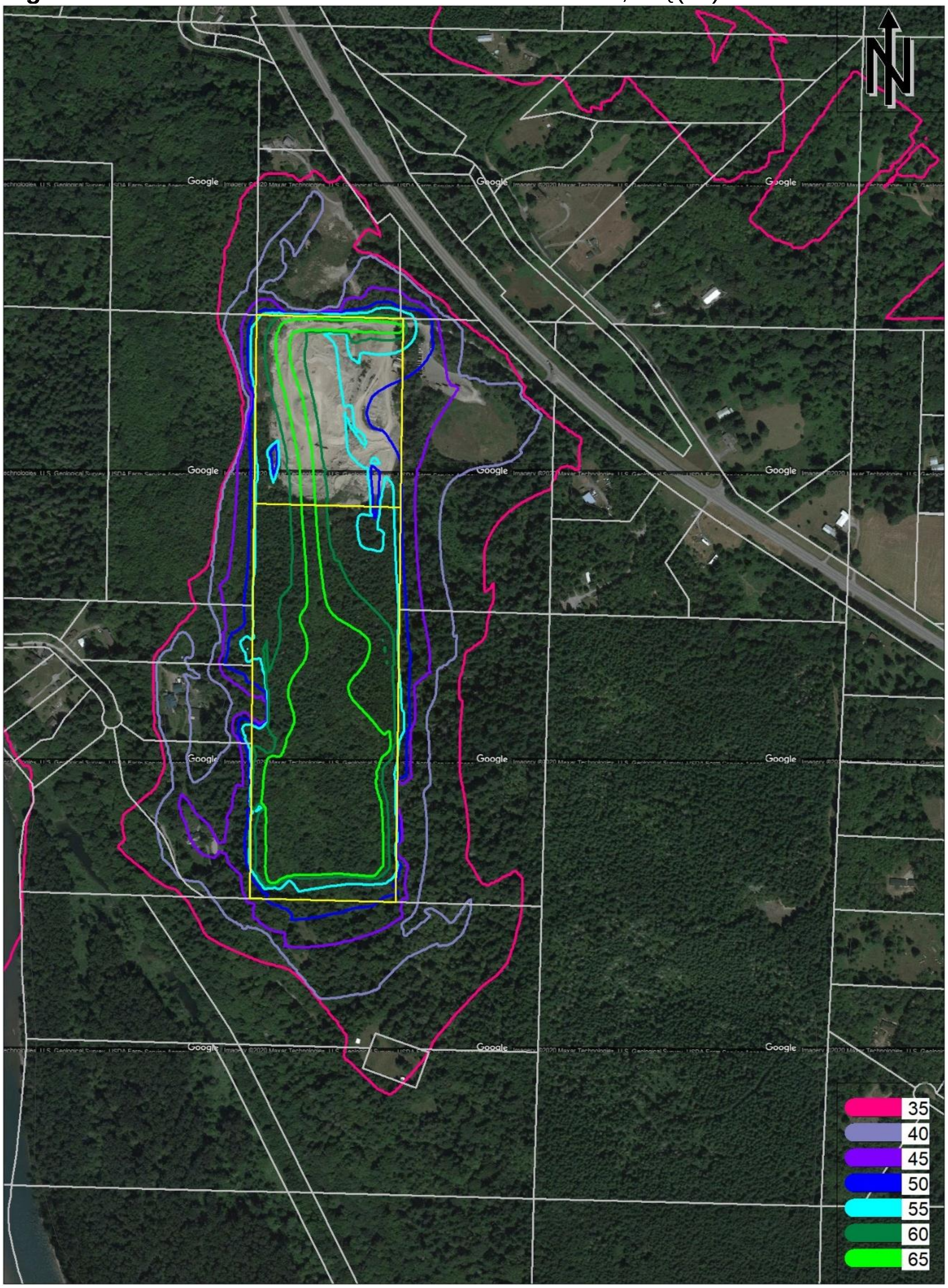


Figure 4. Predicted Sound Level Contours – Phase 3, L_{EQ}(Hr)



Noise Analysis Summary

Table 5 summarizes the predicted sound levels shown in Figure 2 through Figure 4. Additionally, Table 5 provides predicted L_{MAX} sound levels at nearby properties. Predicted L_{MAX} sound level contour figures can be found in the appendix. Sound originating from mining, crushing, and reclamation are predicted to be up to the values shown in Table 5 at nearby properties. These predicted sound levels are at the anticipated loudest location within each parcel, not at dwelling units. Figure 5 shows the location of each parcel listed in Table 5.

Table 5. Predicted Operational Sound Levels and Compliance with Skagit County Code

Receiving Property	Daytime Sound Level Limit, L_{25}/L_{MAX}[B]	Predicted Sound Level, $L_{EQ\ (Hr)}/L_{MAX}$[A]		
		Phase 1	Phase 2	Phase 3
Parcel 1	Easement - No sound limit	66 / 81	66 / 81	66 / 81
Parcel 2	70 / 85	59 / 68	60 / 70	57 / 67
Parcel 3	60 / 75	42 / 47	39 / 46	39 / 46
Parcel 4	60 / 75	37 / 43	31 / 38	34 / 39
Parcel 5	70 / 85	37 / 44	31 / 40	32 / 39
Parcel 6	60 / 75	32 / 36	27 / 30	30 / 35
Parcel 7	60 / 75	30 / 35	27 / 31	28 / 32
Parcel 8	60 / 75	31 / 37	27 / 33	28 / 32
Parcel 9	60 / 75	31 / 37	26 / 34	28 / 31
Parcel 10	60 / 75	38 / 47	39 / 49	37 / 43
Parcel 11	60 / 75	41 / 48	50 / 59	52 / 60
Parcel 12	60 / 75	48 / 55	60 / 65	60 / 66
Parcel 13	60 / 75	48 / 55	60 / 65	58 / 66
Parcel 14	60 / 75	59 / 66	59 / 72	57 / 70
Parcel 15	60 / 75	60 / 72	60 / 72	58 / 72
Parcel 16	60 / 75	54 / 62	55 / 72	50 / 72
Parcel 17[C]	*70 / 85*	62 / 81	62 / 81	62 / 81
Parcel 18	60 / 75	34 / 40	35 / 42	34 / 38
Parcel 19	60 / 75	35 / 49	41 / 48	36 / 45
Parcel 20	60 / 75	35 / 44	37 / 46	35 / 44
Parcel 21	60 / 75	36 / 48	35 / 47	36 / 42
Parcel 22	60 / 75	36 / 48	35 / 46	36 / 42
Parcel 23	60 / 75	35 / 46	34 / 44	36 / 42
Parcel 24	60 / 75	34 / 42	32 / 35	33 / 36
Parcel 25	60 / 75	24 / 33	25 / 33	35 / 42

[A] Expected loudest point on parcel.
[B] Skagit County Code Daytime Sound Level Limits from EDNA C.
[C] Considered a Class C property.

Figure 5. Parcel Number and Location

As shown in Table 5, sound originating from the Site is predicted to comply with sound limits at all properties, if Parcel 17 is considered a Class C EDNA and the mitigation and equipment placement is consistent with what is described in the report. The integrity of all noise berms or walls discussed in this report should be reviewed by qualified personnel.

Optional Mitigation

Mitigation in addition to what has been described in this report may be implemented if Skagit Aggregates feels it is appropriate or if Property 17, just north of the Site, is not considered as a Class C property.

If Property 17 is not considered as a Class C property, then noise mitigation along the northern property line will be required. This mitigation could be a dirt berm or a noise wall constructed of two layers of ¾" inch plywood or another material that has a surface weight of at least 4 pounds per square-foot. The berm or wall should be continuous without holes or gaps. The height of the berm or noise wall should be tall enough so that the haul route is not visible from Property 17. It should be noted that if Property 17 is treated as a Class A property, sound limits would only be exceeded until approximately 15 feet into Property 17, when measured from the property line. The sound limit exceedance would be due to haul trucks driving next to the northern property line. If Property 17 is treated as a Class A property and Skagit aggregates chooses to not build a noise berm or wall along the northern property line, the haul route could be moved so the trucks travel along the eastern property line after entering at the northeast corner of the Site. However, at the time of this report, the haul route travels along the northern property line before turning south, and therefore relocating the existing haul route to the eastern property line would require significant earthwork.

There are three feasible methods to reduce sounds at nearby properties; reduce the amount of sound equipment is producing, reduce the amount of time equipment operates, and use shielding to reduce the amount of noise that reaches nearby properties.

Reducing the amount of noise a piece of equipment produces can be difficult. However, there are some steps that can be taken including:

- Placing a lining or soft material on, or in, areas that have items dropped into them,
- Fit equipment with broadband backup alarms, or ambient sensing broadband backup alarms, where safety requirements can be met, and
- Ensuring all exhaust silencers are fitted properly and are in good working order.

Reducing the amount of time or changing the time of day equipment operates can reduce complaints from residential properties.

- Phasing equipment startups so that multiple pieces of equipment are not starting at the same time. This is especially important during cold starts,
- Reducing the amount of idle time. This is especially important for equipment that utilizes high idle engine speeds,
- Starting and running loud equipment during times of the day when ambient sounds are higher, or nearby properties are less sensitive to noise, and

- Reducing the amount of time equipment operates.

Shielding noise from reaching noise sensitive properties can be an effective method to reduce noise complaints. There are many ways to shield noise, a few methods include:

- Placing loud equipment at lower elevations so excavated walls act as noise barriers,
- Placing equipment so it does not have line-of-sight to noise sensitive properties, and
- Building noise walls around loud equipment. Typical adequate construction is two sheets of ¾" plywood. Noise walls are most effective when very close to the noise source or the receiver of noise.

VIBRATION REGULATORY CRITERIA

The Rockport Crush Plant and all nearby properties are within unincorporated Skagit County; therefore, the Skagit County Code will govern vibration emissions from the Site.

Skagit County Code Chapter 14.16.840(2) states that "every use shall be so operated that the ground vibration inherently and/or recurrently generated from use and/or equipment other than vehicles is not perceptible without instruments at any point on or beyond any zone district boundary in which the use is located."

Chapter 14.16.840(2) is interpreted as prohibiting operations at the mine, or equipment not used on the highway, from producing levels of vibration that are perceptible by humans outside of the Site.

The California Department of Transportation's 2018 Transportation and Construction Vibration Manual provides guidance on the onset of human perception of vibration. Chapter 6 of the manual provides a summary of a variety of studies conducted on the human response to vibration. Findings from these studies include the following:

- An early study by Reiher published in 1931 reports that a PPV of 0.012 in/sec is slightly perceptible to humans if the vibration is continuous.
- A study by Whiffen in 1971 found the perception threshold from continuous vibration produced by traffic is between a PPV of 0.006 and 0.019 in/sec, which is consistent with the findings of the Reiher study.
- In a 1974 study by Wiss it was found that a PPV of 0.035 in/sec from transient vibration is barely perceptible to humans.

Because the studies above show that continuous vibration can be perceived at lower amplitudes than transient vibration, this analysis assumes that vibrations produced by the mine will be continuous in nature.

Skagit County Code Chapter 14.16.840(2) does not provide specific vibration limits. Therefore, a PPV of 0.012 in/sec will be used as the minimum vibration level perceptible by humans and will serve as the mine's vibration limit. This vibration limit will be used in the same manner as a sound limit. However, as described in the Nomenclature section, PPV is an instantaneous value, not an average. Therefore, because it is unlikely that the

PPV from multiple pieces of equipment will occur simultaneously, PPV will be analyzed for each piece of equipment individually instead of combining PPV values from multiple pieces of equipment.

Table 6. Ground Vibration Limit, PPV (in/sec)

Receiving Property	Vibration Level
All	0.012 in/sec

VIBRATION ANALYSIS

Vibration measurements were made of activities and equipment operating at Skagit Aggregates' Big Rock Pit and Big Lake Pit on May 26th, 2021. The equipment and activities measured on May 26th, 2021 are similar to the activities and equipment that will operate at the Rockport Crushing Plant and will be used to determine the distances necessary for vibration produced by these activities to dissipate to below the ground vibration limit shown in Table 6. The vibration source levels measured on May 26th, 2021, and used in this analysis are summarized in Table 7.

Table 7. Measured Vibration Levels

Equipment/Activity	Vibration Level, PPV	Distance from Source
Excavator Operating	0.021 in/sec	35 feet
Excavator Moving	0.045 in/sec	35 feet
General Loader Activity	0.015 in/sec	80 feet
Loading Dump Trucks	0.012 in/sec	60 feet
Dozer Operating	0.025 in/sec	30 feet

Dump trucks and other vehicles that operate on public highways are exempt from vibration regulations identified in the Skagit County Code and are excluded from this analysis. Vibration levels created by dump trucks are typically lower than other equipment that would operate at the site due to their rubber tires and suspension. The Terex Finlay J-1160 Jaw Crusher and C-1540 Cone Crusher are omitted from this analysis because they rarely move and the hoppers and crusher are on spring isolation. Additionally, the crushers must operate at least 200 feet from a property boundary as required by the mine's buffer distance.

Unlike airborne sound, which typically propagates uniformly from a source and dissipates over distance at a consistent rate, vibration propagation through soil varies depending on soil conditions and other site-specific factors. To more accurately predict vibration levels from the site, measurements were made of the site-specific vibration propagation characteristics on March 8, 2023. Vibration propagation measurements consist of repeatedly dropping a heavy mass onto the ground to produce a seismic wave and measuring the resulting vibration levels at several distances. The vibration levels are then compared to determine the vibration reduction over distance, also known as the vibration spreading coefficient. Equipment used during the vibration propagation measurements is shown in Table 8.

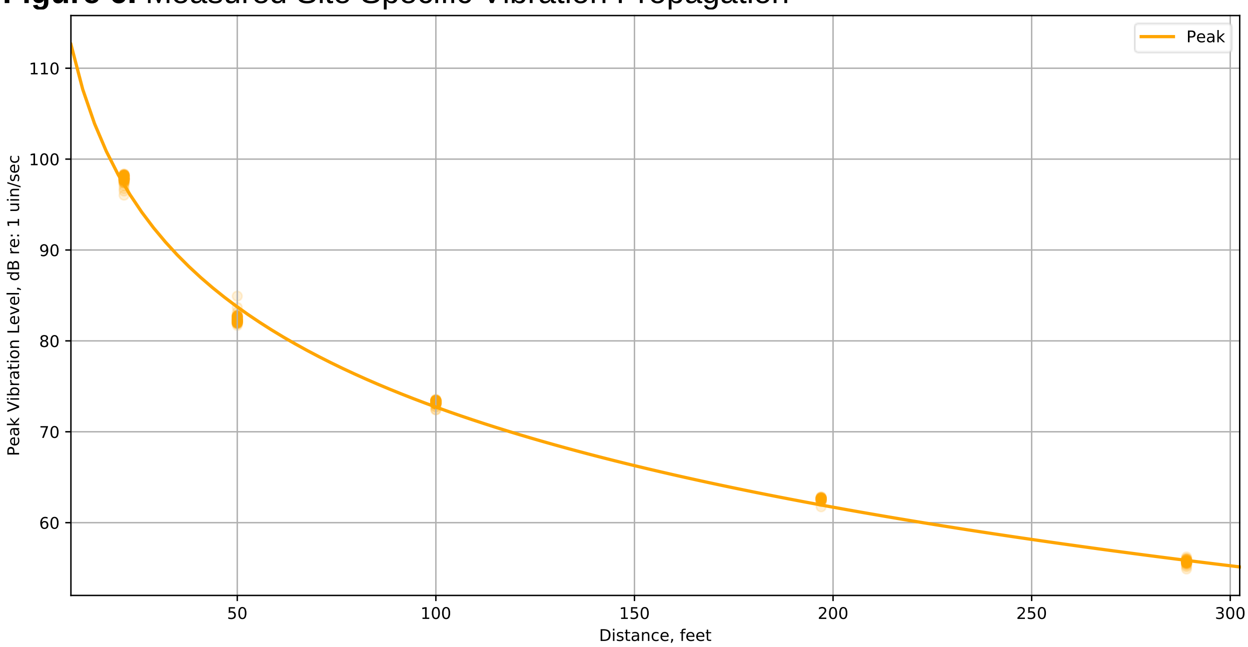
Table 8. Vibration Propagation Measurement Equipment

Make and Model	Description	Serial Number
Tascam 680MKII	Digital Audio Recorder	80239
PCB 482A16	Signal Conditioner	2987
PCB TLD333B50	Accelerometer	58927
PCB TLD333B50	Accelerometer	64178
PCB 393B31	Accelerometer	70769
PCB 393B31	Accelerometer	70768
PCB 394B06	Vibration Calibrator	0971

Vibration levels were measured at five distances from the vibration source. Twenty-eight measurements were made 22 feet, 50 feet, 100 feet and 197 feet from the source and an additional 35 measurements were made with the 197-foot distance relocated to 289 feet from the source.

The results of the site-specific vibration propagation measurements and the best fit curve showing the vibration reduction over distance is shown in Figure 6.

Figure 6. Measured Site Specific Vibration Propagation



The distances necessary for vibration produced by equipment and activities at the site to dissipate to below the project's vibration limit were calculated using the measured vibration levels and site-specific vibration propagation characteristics. Distances required for vibration to attenuate to below the vibration limit are referred to as impact distances and are the distances equipment and activities should remain from the property lines to avoid causing a vibration exceedance. These impact distances are shown in Table 9.

Table 9. Vibration Impact Distances, Feet

Equipment/Activity	Impact Distance
Excavator Operating	48
Excavator Moving	72
General Loader Activity[A]	91
Loading Dump Trucks	61
Dozer Operating and Moving	45

[A] Loader bucket scraping hard packed ground highest energy event

Mining operations must maintain at least a 100 foot buffer distance from neighboring properties, except during reclamation. Because all vibration impact distances are less than 100 feet, no vibration exceedances are anticipated during mining. The loader may operate within 100 feet of neighboring properties during reclamation, but it is expected to produce lower levels of vibration than when it operates on the pit floor due to the embankment and compaction of the soil near the property lines.

Appendix A
Noise Measurement Equipment
Source Measurements

Table A1. Noise Measurement Equipment

Item	Manufacturer - Model	Serial Number	Calibration Date
Sound Analyzer	Svantek - 958A	59108	2/17/2021
Preamplifier	Svantek – SV12L	57961	
Microphone	MG – MK55	12529	
Calibrator	Larson Davis – CAL200	16826	

Figure A1. Typical Noise Measurement Setup

Appendix B
Noise Modeling Parameters

Table B1. Cadna/A Parameters

Sound Source	Parameter	
	L_{EQ} (Hr)	L_{MAX}
Dump Truck	5 Trucks per Hour Unloaded truck speed – 20 mph Loaded truck speed – 10 mph	Inactive, Pass-by levels accounted for outside of Cadna/A L_{MAX} sound contours.
Excavator	Active 9 Minutes per Hour (15%)	Inactive
Dozer	Active 15 Minutes per Hour (25%)	Active, producing L_{EQ} sound level
Loading Trucks (Loader and Truck Noise)	Active 20 Minute per Hour (4 minutes per truck load)	Active, producing L_{MAX} sound level
Loader (mining operation)	Active 24 Minutes per Hour (40%)	Active, producing L_{MAX} sound level
Loader (reclamation)	Active 15 Minutes per Hour (25%)	Inactive
Jaw Crusher	Active 45 Minutes per Hour (75%)	Active, producing L_{EQ} sound level
Cone Crusher	Active 45 Minutes per Hour (75%)	Active, producing L_{EQ} sound level

Modeled Noise Source Locations

Figure B1. Phase 1

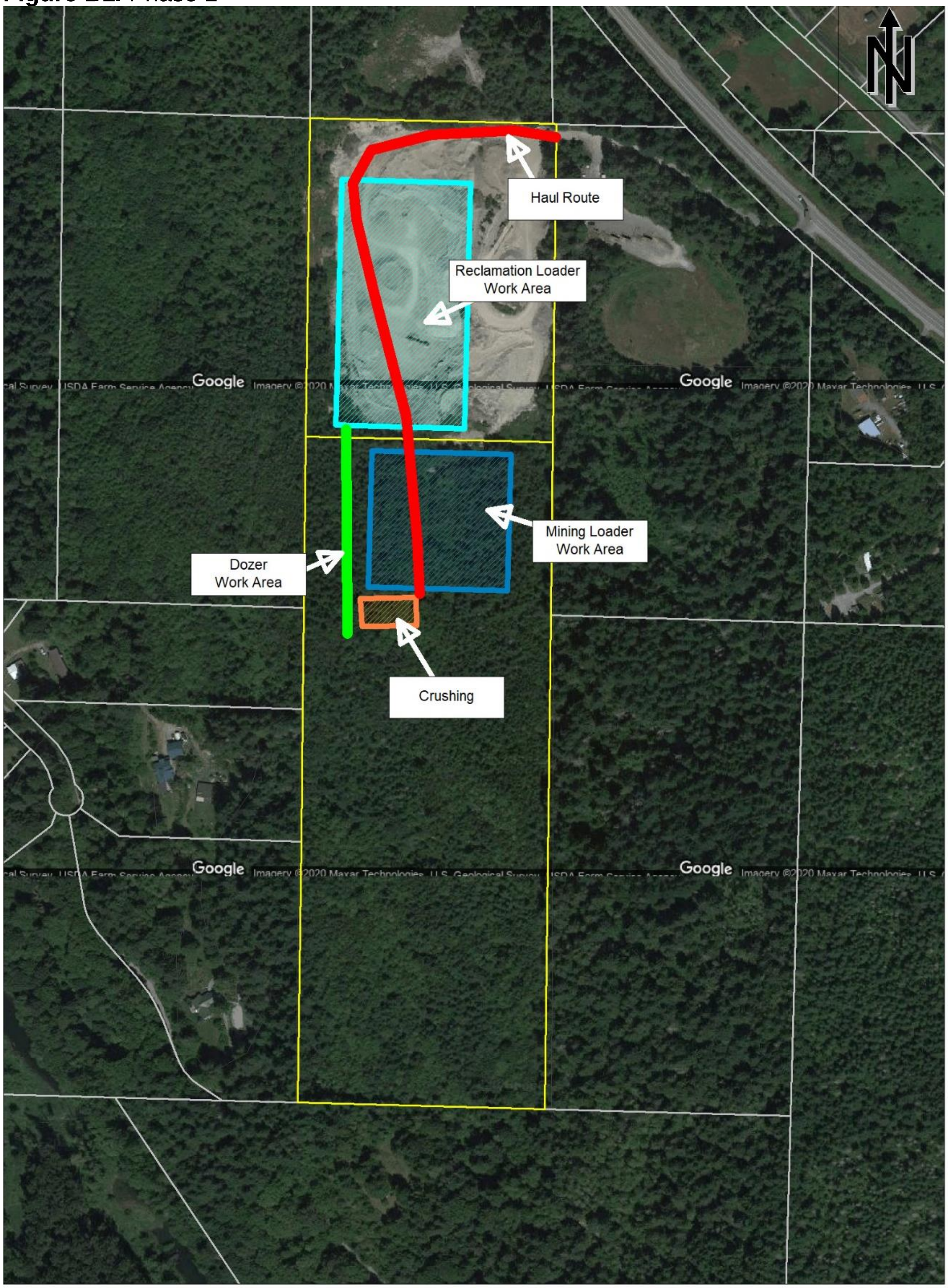


Figure B2. Phase 2

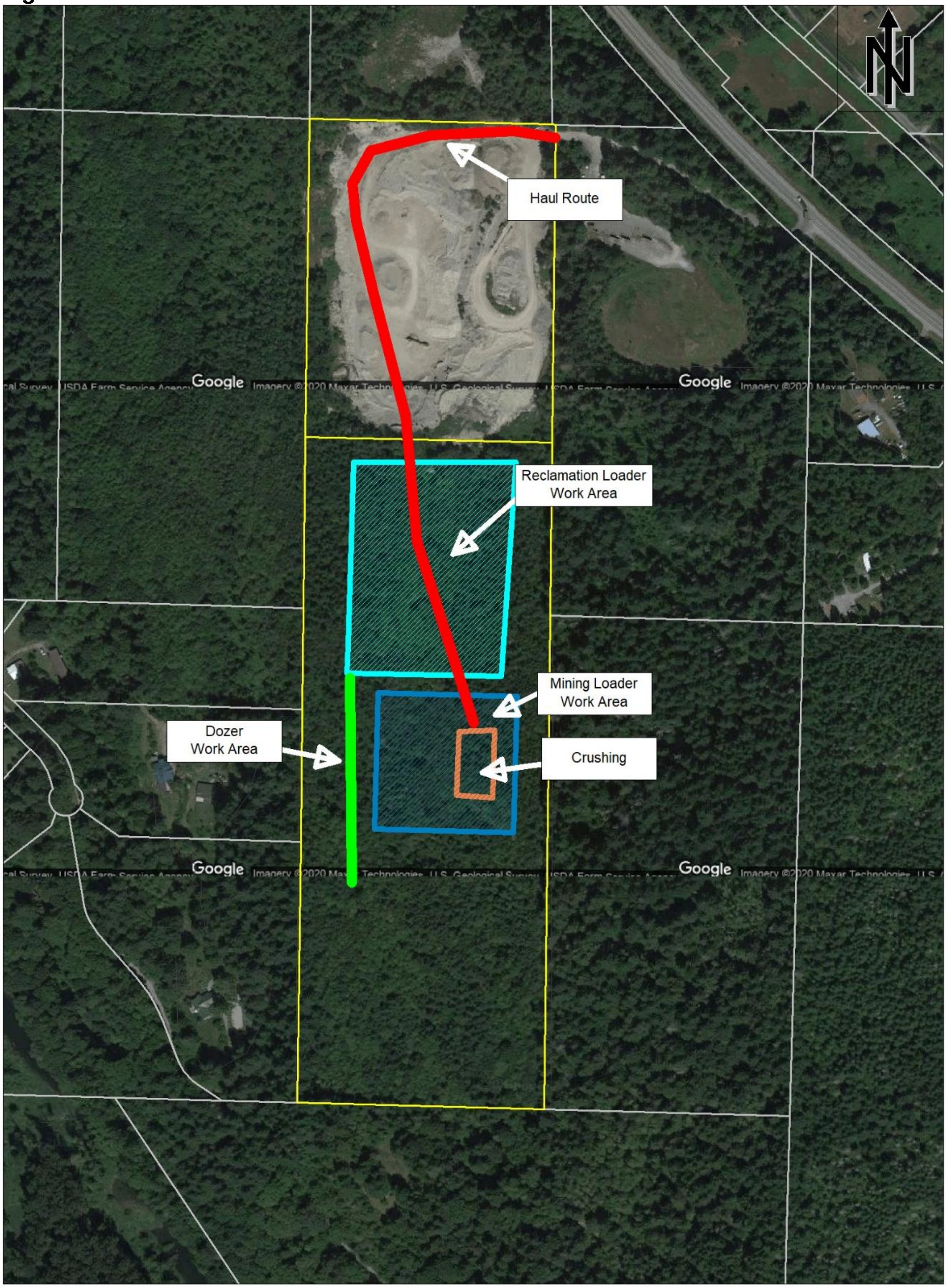
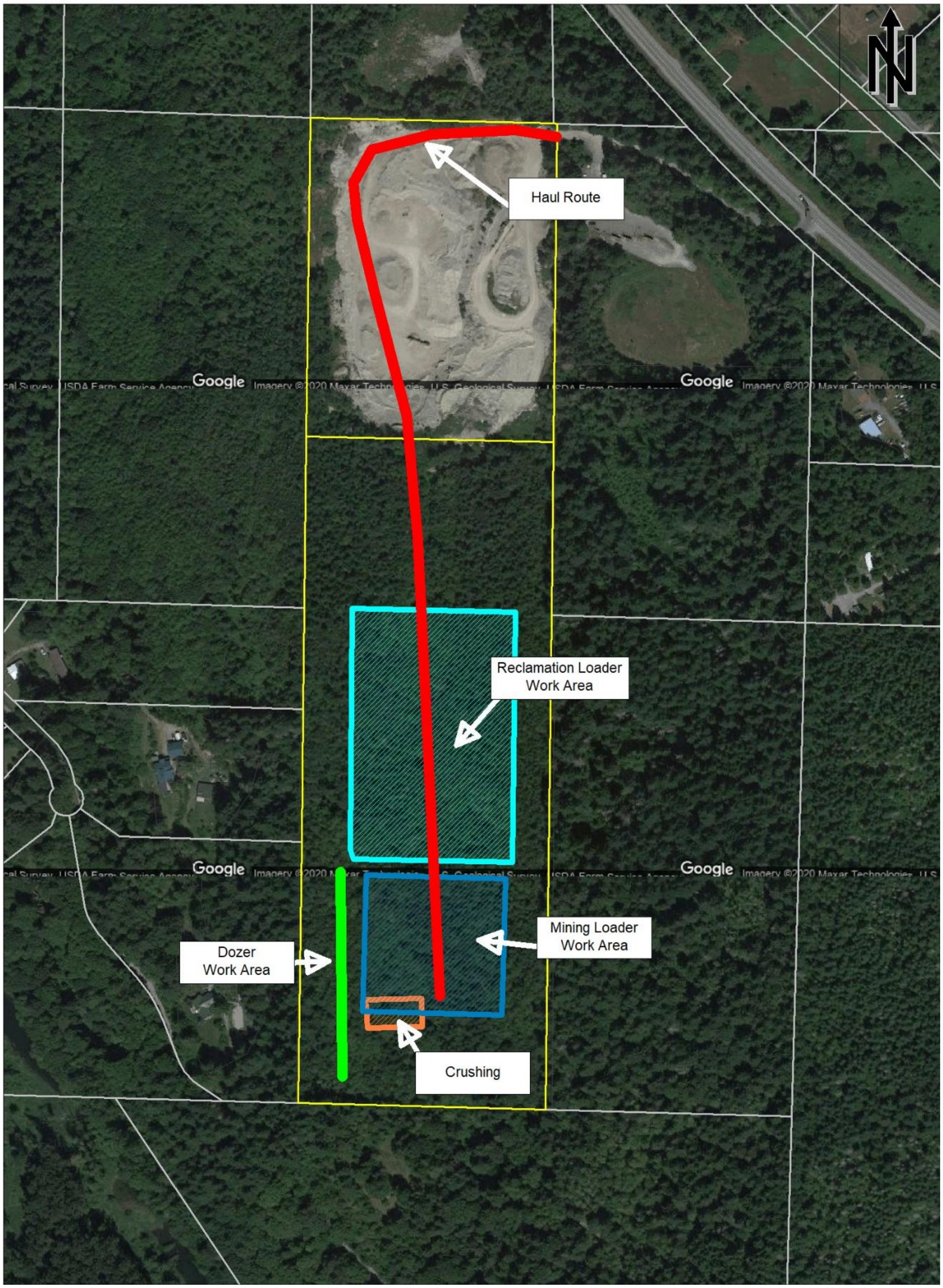


Figure B3. Phase 3



Appendix C

L_{MAX} sound level contours do not include haul truck pass-bys which were accounted for outside of these contours.

Figure C1. Phase 1 Predicted Sound Level Contours, L_{MAX}

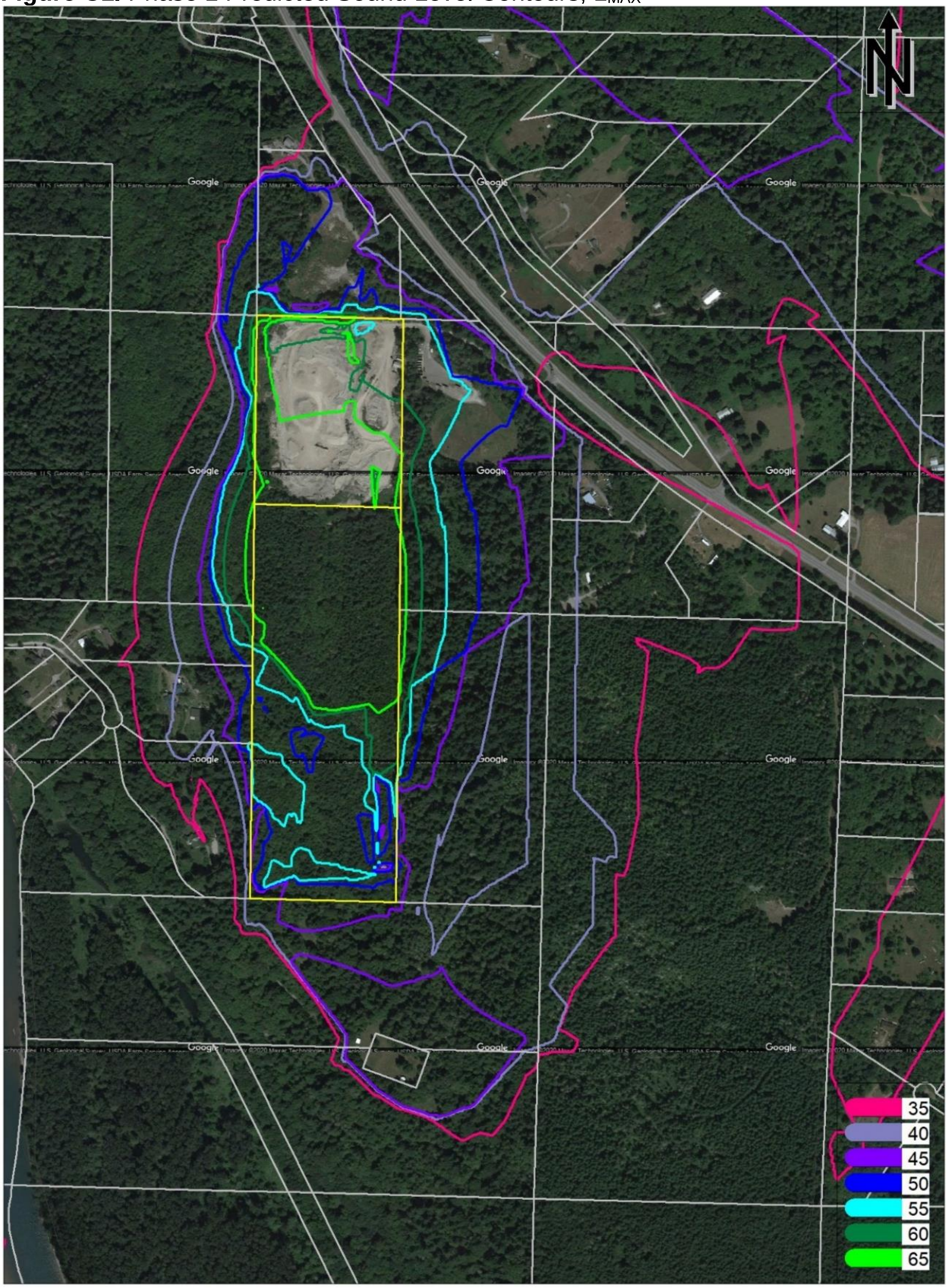


Figure C2. Phase 2 Predicted Sound Level Contours, L_{MAX}

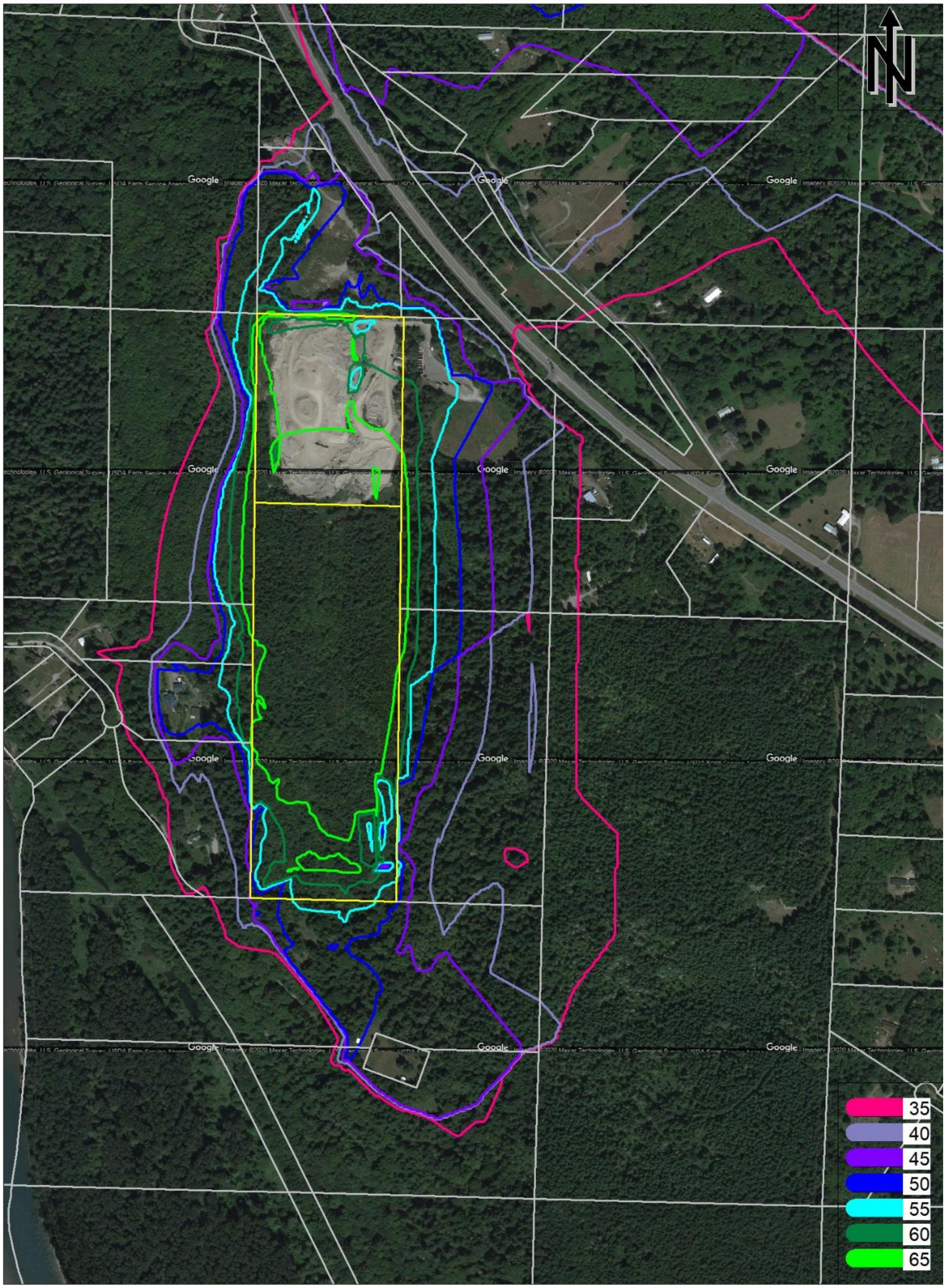
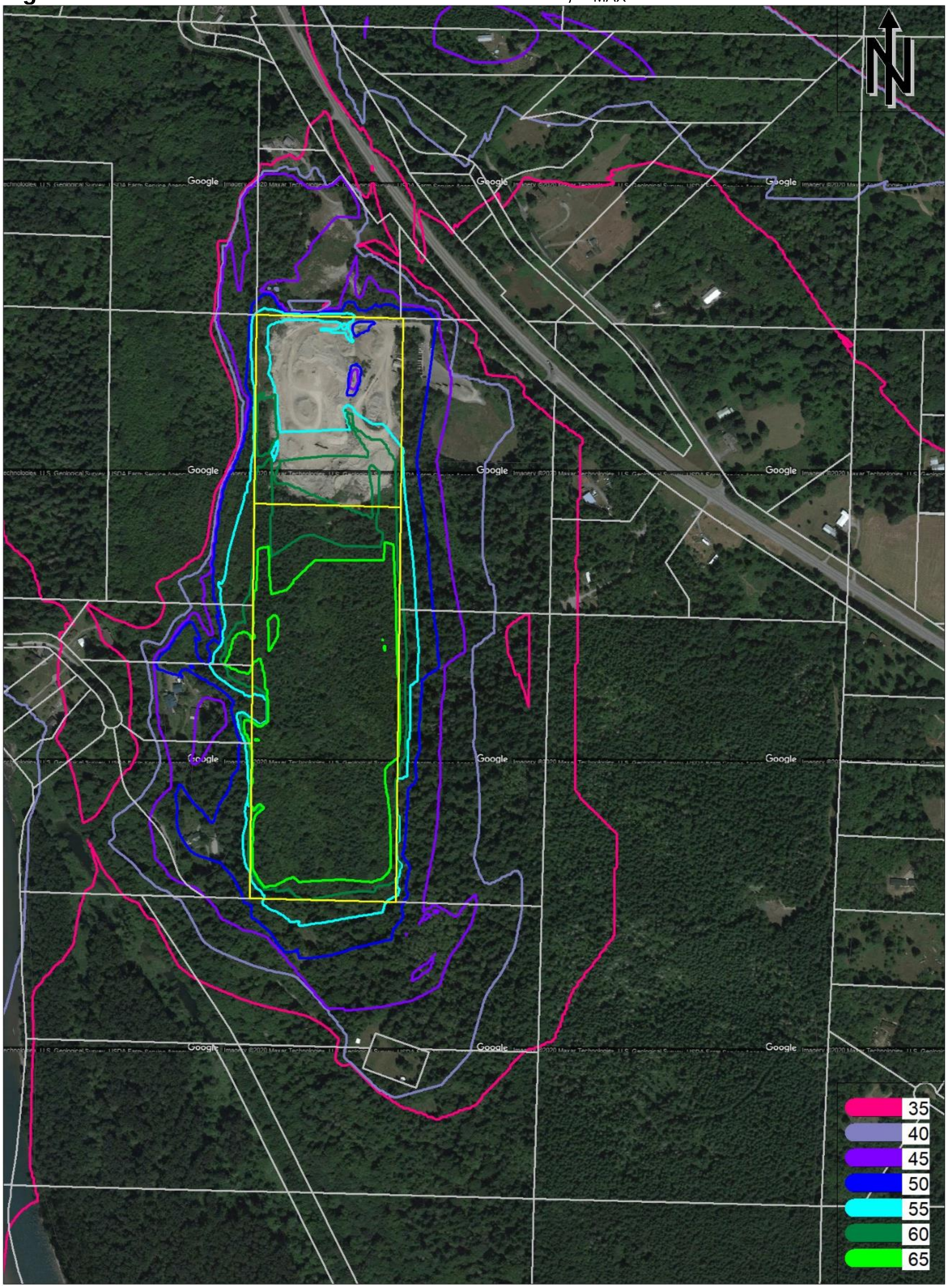


Figure C3. Phase 3 Predicted Sound Level Contours, L_{MAX}



Appendix D

Vibration Measurement Equipment

Source Measurements

Table D1. Vibration Measurement Equipment

Item	Manufacturer - Model	Serial Number	Calibration Date
Vibration Analyzer	Svantek - 958A	59108	2/17/2021
Recorder	Tascam 680 MKII	80239	Not Required
Accelerometer	PCB TLD333B50	58927	07/06/2021
Accelerometer	PCB TLD333B50	64178	08/10/2020
Accelerometer	PCB TLD333B50	64179	07/06/2021
Accelerometer	PCB TLD333B50	64180	08/10/2020
Accelerometer	PCB TLD333B50	64181	07/06/2021
Shaker (Calibrator)	PCB 394B06	0971	11/16/2020

Figure D1. Typical Vibration Measurement Setup

Appendix E
Vibration Propagation Measurement and Details

Figure E1. Vibration Propagation Measurement Setup