R|S|G INC.
RESOURCE SYSTEMS GROUP, INC.

MEMORANDUM

To:	Greg Adamovich
From:	Kevin Hathaway and Kenneth Kaliski, P.E.
Subject:	Response to Item #4 on the District Environmental Commission's Hearing Recess Memo
Date:	13 September 2004

At the request of the District Environmental Commission, we are providing results for the four questions pertaining to noise impacts from your proposed stone quarry in Gassetts, Vermont. We utilized noise modeling and statistical methods to address the questions. Figure 1 identifies the study area and the location of the modeled receivers[1].

We considered noise impacts at 31 homes (receivers) in the broader vicinity of the proposed quarry. These included homes both further removed from VT 103 and the homes directly adjacent to VT 103. Sound level modeling was completed for the project using CADNA/A acoustical modeling software. This modeling tool, made by Datakustik GmbH, is an internationally accepted acoustical model, and is used by many other noise control professionals in the United States and abroad. The software has a high level of reliability and follows methods specified by the International Standards Organization in their ISO 9613-2 standard, "Acoustics – Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation." The standard states,

> "This part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level … under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation … propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night."

The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, foliage, berms, and terrain.

A 5 meter by 5 meter grid of receivers was set up covering over 1400 acres in and around the site. In addition, discrete receivers were placed at the nearest residential homes. The locations of the 31 discrete

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[1] These receiver locations are for all residential buildings in the area taken from the Vermont E911 (Emergency 911) database for all buildings in Vermont.

receivers are shown in Figure 1. In that Figure, we can see receivers located along VT 103, Route 10, Clemons Road, Brooks Road, and Blackberry Road. The modeling assumed that the quarry was beyond the initial start-up and at full operation with all equipment present.

We modeled both instantaneous maximum and average (Leq) sound pressure levels for each receiver (See Receivers A-EE in Figure 1). The modeling included the following sources of noise:

1) Hydraulic Rock Drill
2) Excavator
3) Loader
4) 70-ton Rock Splitter
5) 300-ton Rock Splitter
6) Haul Trucks on the Quarry Driveway

Four modeling scenarios were considered (A, B, C & D). The four scenarios represent the placement of the machinery at four different locations in the quarry. This was done to be comprehensive in understanding potential quarry impacts over the life of the project.

The modeling also considered two quarry conditions:

1) Periods with drilling
2) Periods without drilling

Drilling is expected to be used for 12 hours per month on any day of the work week except Saturdays, and thus was considered separately to accurately assess impacts. Our model assumed the drill operated in addition to the normal quarry equipment.

What would the Lmax noise measurement be at the nearest area of common use with the project operating and no traffic on route 103?

Based on estimates that you provided of equipment operating times, we modeled sound pressure levels from all quarry equipment at the nearest area of common use. Lmax is defined here as LAeq 1-second instantaneous maximum sound pressure level. The nearest area of common use was determined to be Mr. Henry Bushee's home (Receiver O in Figure 1), located to the West of the quarry driveway between the railroad tracks and the Williams River. During Phase 1, material is planned to be extracted from the northern end of the proposed quarry. At this time, quarry equipment will be at their closest point to a residential home (about 280 feet).

The modeling indicates that the hydraulic drill will likely create the highest sound pressure levels at this home. This is due to its drilling position on the higher edges of the quarry wall. The remaining equipment operates on the quarry floor. As previously noted, drilling is estimated to be needed for roughly 12 hours per month (generally over two days). During these hours at initial quarry extraction (Scenario A), the maximum levels from the drill are predicted to be near 74 dBA at this home (Figure 3). These levels could occur for less than one second at the beginning of each new drilling hole when the drill bit penetrates the rock surface. After penetration, the drill noise drops by as much as 8 dB for the remainder of the hole. Table 1 shows that under at different stages of quarry activity (Scenarios B, C, and D), the maximum level at Mr. Bushee's home will be between 55 and 57 dBA.

However, on the majority of working days, the drill is not present. During these more typical periods, Lmax levels will be significantly lower than 74 dBA (between 55 and 57 dBA) at Mr. Bushee's home.

What percentage of the time is the Lmax at houses greater than 55 (Current Condition)?

To answer this question, we examined previously collected long-term monitoring data. From March 25th to March 30th, 2004, a sound level meter was placed on the East side of VT 103 (see Figure 1) at the same distance from VT 103 as the homes. We collected one-minute data for LAeq, LFmax, L1, L10, L50, L90 and L95[1]. Given that we had one-minute statistics for sound levels, we examined the data to approximate what percentage of the time in a given minute the sound level exceeded 55 dBA. This was done using linear approximation by the "least squares" method.

This analysis method was done for the 2,094 monitored minutes that fell into normal quarry operating hours (7:00 am to 5:00 pm M-F plus 4 possible hours on Saturday). Performing this method for all minutes, adding up the total seconds over 55 dBA (91,594 seconds), and then dividing by the total number of seconds considered (125,640 seconds) gives us our total estimate.

Our results indicate that the homes adjacent to VT 103 (East side) experience Lmax sound levels over 55 dBA 73% of the time between 7:00 am and 5:00 pm, Monday through Saturday.

What percentage will the Lmax be greater than 55 with the proposed quarry?

We have established that the homes along VT 103 experience sound levels above 55 dBA for much (73%) of the quarry work day already. Our challenge here is to establish how often during the day the quarry will add enough additional noise to raise this percentage above 73%.

This problem is more complex than might first be expected, since traffic noise occurs at random intervals during the day. Randomness means that in a given workday, we know cars and trucks will drive by on VT

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[1] L1 = sound level exceeded 1% of the time, L10 = sound level exceeded 10% of the time, L50 = exceeded 50% of the time, etc.

103, but we could not predict exactly when in the day traffic events would occur. Similarly, we can't predict with any certainty at which seconds in a day a drill would create an Lmax sound level.

When uncertainty such as this exists, we use probability models to estimate occurrence. Probability models are useful and reliable ways to estimate the likelihood of events. Based on the estimates you provided regarding equipment use, we know the probability of each quarry machine to create a given sound level at the homes. For example, if we assume the rock splitters operate for 5 hours (300 minutes) a day, we know they will generate their Leq sound levels with a probability of 0.50, or 50% (300 minutes is 50% of a 10-hour work day). Additionally, from sound level monitoring at your existing quarry, we were able to identify the amount of time the equipment generates Lmax levels. The probability model randomly assigns these events (both Leq and Lmax for all machinery) at the amount they occur throughout the day. The resulting output accounts for all times when the quarry, VT 103 traffic, or both are generating levels over 55 dBA.

Since sound propagation is different depending on the location of the receiver and the source, each home along this stretch of VT 103 will have a slightly different result. If we consider the homes with the greatest potential for quarry noise impact, we will have a conservative estimate for all other homes along VT 103. The two residential homes from Table 1 with the highest predicted sound levels from the quarry (Receivers O and J) were analyzed. We modeled all quarry equipment noise for these two receivers, and ran our probability model across an entire workday. The quarry noise was assigned randomly across that day, as to mimic how quarry noise will be generated. These noise levels, coupled with the existing VT 103 traffic were added together. Finally, we summed all the periods when total sound levels were above 55 dBA. As before, we considered days with drilling and days without drilling.

Our modeling indicates that with typical quarry operations (no drill), **sound levels at the homes could be over 55 dBA an additional 1% to 3% of the time** (74% to 76% total), representing a small increase over the existing condition from traffic noise at 73%. The range (1% to 3%) presented here is due to the randomness of both quarry noise and traffic noise. Some days, more overlap of quarry noise and traffic noise will occur, hence the low estimate of the 2% increase. The reasoning here is because when traffic noise and quarry noise occur simultaneously (overlap), than there are fewer additional periods over 55 dBA. On other days, quarry noise and traffic noise may overlap less (occur at different times = more periods over 55 dBA) producing the higher estimate of 76%.

On the two days when drilling is present, **sound levels at the homes could be over 55 dBA an additional 13% to 15% of the time** (86% to 88% total). The range is for the same reasons discussed above. This represents a worst-case probability model with the drill at its closest point and located high on the quarry rim. It is likely that on the majority of drilling days for the life of the quarry, the time over 55 dBA will be lower than the estimates provided here.

What will the impact of noise be on homes further removed from route 103?

Leq levels[1] for each receiver are provided in Table 2. For the majority of time (periods of no drilling), Leq levels from quarry noise are predicted to be lower than 50 dBA at all receivers. On the two days a month when drilling does occur, Leq levels will be higher at most receivers. Figure 4 (without drilling) and Figure 5 (with drilling) show the maximum Leq levels expected across all four scenarios[2]. The homes further removed from VT 103 (located along Route 10, Clemons, Brooks, and Blackberry Roads) will have quarry-related Leq levels below 50 dBA for both drilling and non-drilling periods.

We have also modeled instantaneous maximum sound levels. Instantaneous maximums represent 1-second levels that are possible throughout a workday. Again, we've broken the modeling into the drilling and non-drilling conditions. Table 1 shows the results of the modeling. Figures 2 (without drilling) and 3 (with drilling) show the maximums[3] expected across all four scenarios. Homes further removed from VT 103 will experience maximum levels below 52 dBA during drilling and non-drilling periods.

SUMMARY

We conducted sound level modeling and statistical analysis to address the four questions asked by the District Environmental Commission. The results for each question are summarized below:

What would the Lmax noise measurement be at the nearest area of common use with the project operating and no traffic on route 103?

Our sound level modeling indicates that in the early stages of the project when the drill is in areas close to Mr. Bushee's home, Lmax levels could reach 74 dBA. As mentioned above, these will be infrequent events and of short duration. As the project progresses, Lmax levels are expected to be well below 74 dBA at all receivers.

What percentage of the time is the Lmax at houses greater than 55 (Current Condition)?

Traffic along VT 103 is heavy, and thus Lmax sound levels at these homes are above 55 dBA 73% of the time between 7:00 am and 5:00 pm.

What percentage of the time will the Lmax be greater than 55 with the proposed quarry?

The quarry will generate additional noise in the nearby vicinity. However, noise impacts will be small for much of the time. Based on the estimates of machinery operating times, quarry noise will cause a 1% to

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[1] Leq levels presented here are for quarry noise only and do not include existing background noise (ie. traffic, birds, insects, etc).

[2] These values are the spatial representation of the maximum Leq levels from Table 2.

[3] These values are the spatial representation of the maximum levels from Table 1.

3% increase (74% to 76% total) in the amount of time homes experience levels over 55 dBA during non-drilling operations. During drilling operations for two days per month, sound levels could exceed 55 dBA as much as 88% of the time.

What will the impact of noise be on homes further removed from route 103?

The homes further removed from VT 103 will experience small noise impacts from this quarry. Modeling indicates that Leq sound levels at these further homes will be less than 50 dBA for the life of the quarry.

Instantaneous maximum sound levels from the proposed quarry will be generated mostly by the hydraulic rock drill and excavator. The maximum levels presented in Figures 2 and 3 will occur for less than 1 second at a time. Homes further removed from VT 103 will experience maximum levels below 52 dBA during drilling and non-drilling periods.

Figure 1: Study Area with Modeled Receivers (Labeled A-EE)

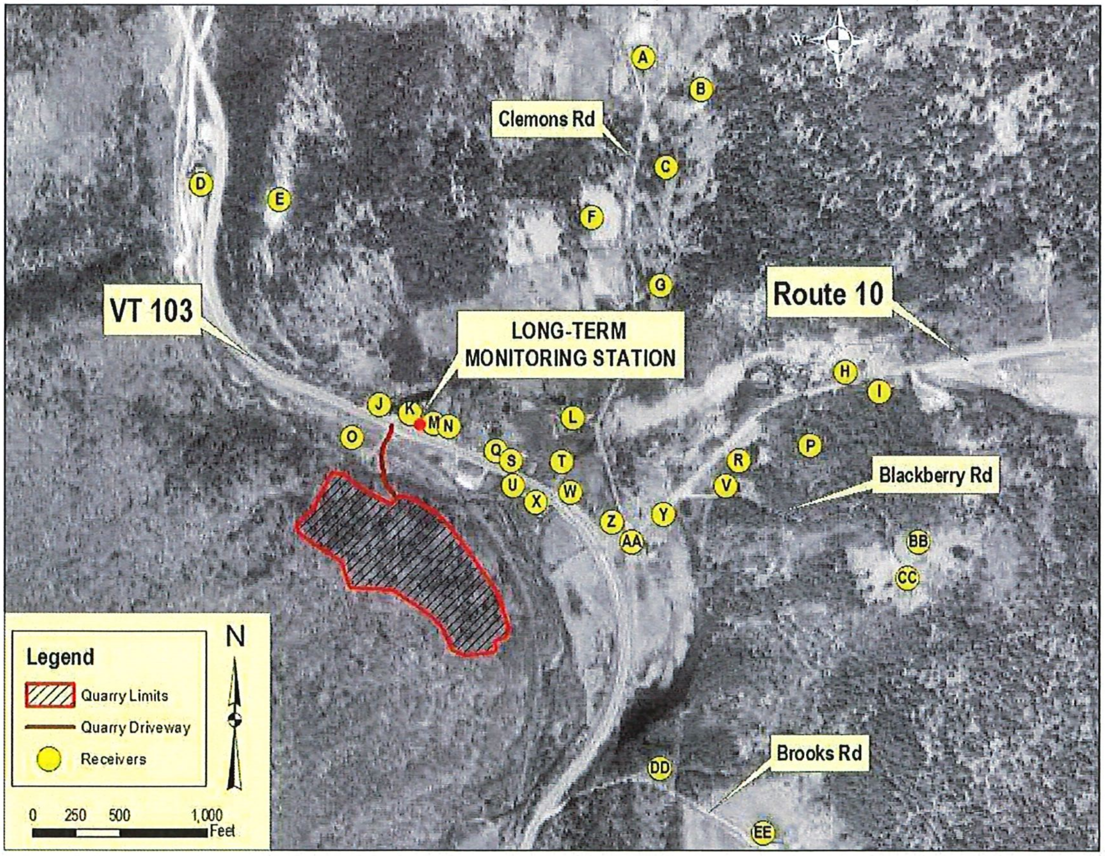

Table 1[1]: Instantaneous Maximum Modeling Results for All Receivers in dBA

Receiver	Adjacent Street	Days without Drilling				Days with Drilling			
		Scenario A	Scenario B	Scenario C	Scenario D	Scenario A	Scenario B	Scenario C	Scenario D
A	Clemons	41	42	42	42	41	42	42	42
B	Clemons	40	42	42	42	40	42	42	42
C	Clemons	42	43	43	42	42	43	43	42
D	VT 103	39	39	39	39	39	39	39	39
E	VT 103	50	50	50	50	50	50	50	50
F	Clemons	34	42	44	43	39	42	44	43
G	Clemons	43	45	44	44	44	45	44	44
H	Route 10	43	43	43	41	43	43	43	41
I	Route 10	43	43	44	42	43	43	44	42
J	VT 103	54	54	59	57	69	54	59	57
K	VT 103	57	57	60	57	68	57	60	57
L	Clemons	48	50	50	50	52	50	50	50
M	VT 103	53	54	57	54	66	54	57	54
N	VT 103	53	55	56	53	65	55	56	53
O	VT 103	57	55	55	57	74	55	55	57
P	Route 10	47	47	50	47	47	47	50	47
Q	VT 103	51	54	54	56	62	54	55	56
R	Route 10	46	46	47	47	46	46	47	47
S	VT 103	55	55	55	55	61	55	55	55
T	VT 103	52	52	53	55	53	52	53	55
U	VT 103	50	50	52	53	59	50	52	53
V	Blackberry	47	47	48	48	47	47	48	48
W	VT 103	49	51	55	57	54	51	55	57
X	VT 103	48	49	51	61	52	49	51	61
Y	Route 10	46	49	51	51	51	49	51	51
Z	VT 103	49	51	56	55	54	51	56	55
AA	VT 103	49	51	56	54	52	51	56	54
BB	Blackberry	35	41	41	34	39	41	41	34
CC	Blackberry	44	45	46	43	44	45	46	43
DD	Brooks	50	50	50	50	50	50	50	52
EE	Brooks	50	50	50	50	50	50	50	50

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[1] Figures 2 & 3 show the highest level for each receiver across all four scenarios for both non-drilling and drilling periods.

Figure 2: Instantaneous Maximum Sound Levels for Quarry Operations without Drilling (in dBA)

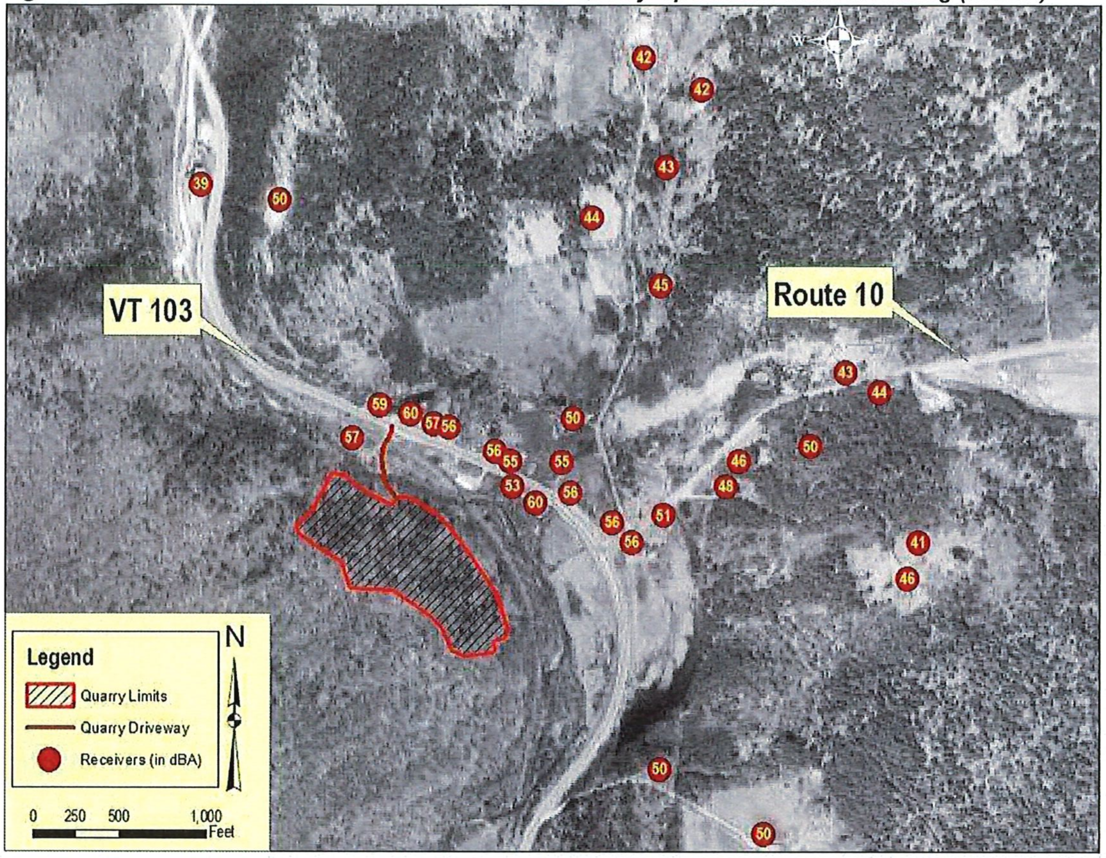

Figure 3: Instantaneous Maximum Sound Levels for Quarry Operations with Drilling (in dBA)

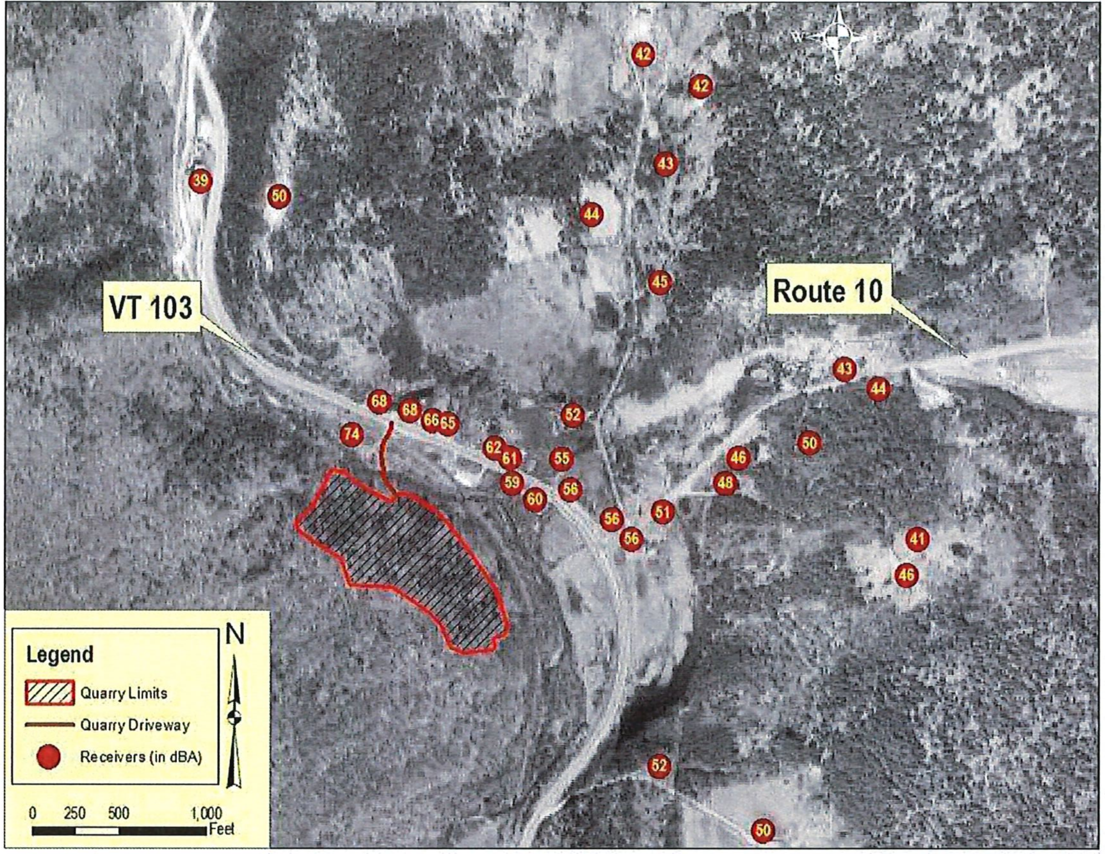

Table 2[1]: Leq Modeling Results for All Receivers in dBA

Receiver	Adjacent Street	Days without Drilling				Days with Drilling			
		Scenario A	Scenario B	Scenario C	Scenario D	Scenario A	Scenario B	Scenario C	Scenario D
A	Clemons	29	30	30	30	35	32	36	32
B	Clemons	27	29	29	29	34	31	36	31
C	Clemons	31	31	31	31	36	33	37	33
D	VT 103	25	28	26	27	28	32	29	28
E	VT 103	40	40	40	40	43	41	41	40
F	Clemons	23	29	30	30	33	32	38	33
G	Clemons	31	33	32	32	39	35	38	34
H	Route 10	32	33	33	31	38	34	36	32
I	Route 10	33	33	33	32	38	34	37	33
J	VT 103	45	45	48	47	63	47	49	47
K	VT 103	47	47	49	47	62	48	51	48
L	Clemons	37	38	38	38	47	40	43	40
M	VT 103	44	44	45	44	61	46	49	45
N	VT 103	44	44	45	44	59	46	49	45
O	VT 103	47	45	46	47	69	47	47	47
P	Route 10	36	37	39	37	41	37	40	38
Q	VT 103	42	43	43	44	56	45	50	46
R	Route 10	35	35	36	36	41	37	39	38
S	VT 103	43	45	44	45	55	46	49	47
T	VT 103	41	41	42	43	48	43	47	45
U	VT 103	41	40	41	42	53	43	47	44
V	Blackberry	36	37	37	37	42	38	40	39
W	VT 103	39	40	42	44	49	42	47	46
X	VT 103	39	39	40	47	47	42	46	48
Y	Route 10	36	37	39	39	46	39	42	41
Z	VT 103	38	40	43	42	48	41	46	45
AA	VT 103	38	40	43	42	46	41	46	45
BB	Blackberry	25	28	29	24	34	31	31	29
CC	Blackberry	35	35	35	34	38	36	38	37
DD	Brooks	39	38	39	38	42	39	44	47
EE	Brooks	38	37	38	37	42	37	42	42

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[1] Figures 4 & 5 show the highest level for each receiver across all four scenarios for both non-drilling and drilling periods.

Figure 4: Maximum Predicted Leq Sound Levels for Quarry Operations without Drilling (in dBA)

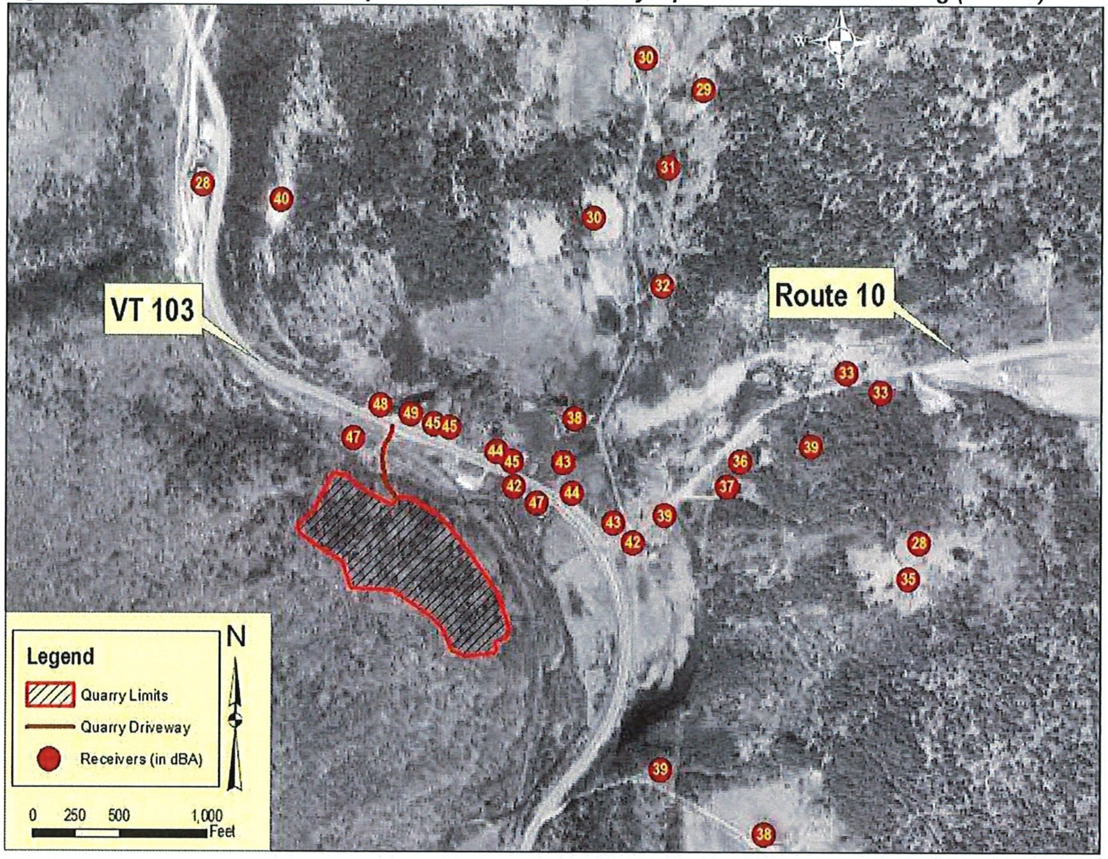

Figure 5: Maximum Predicted Leq Sound Levels for Quarry Operations with Drilling (in dBA)