Appendix D

Duble Noise Study

NOISE IMPACT STUDY

HOWARD CANYON QUARRY

MULTNOMAH COUNTY

OREGON

FOR

WINTER BROOK PLANNING

AND

MULTNOMAH COUNTY LAND USE

PLANNING DIVISION

JULY 16, 2002

By

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NOISE IMPACT STUDY **JULY 2002**

HOWARD CANYON ROCK QUARRY
MULTNOMAH COUNTY, OREGON
INTRODUCTION

In February and March, 2002, a study of the noise impacts of a proposed expansion of the Howard Canyon Rock Quarry, owned by Interstate Rock Products of Washougal, Washington, was completed. Ambient noise was measured at seven residential sites near the existing and proposed expansion areas. The noise of rock extraction and processing sources were also measured. Estimated future noise of these sources was calculated with the aid of a computer propagation program, and the results were compared to ambient noise and the State DEQ noise standard. Finally, noise impacts were described based on the DEQ standard, and on a livability standard based on increases of proposed quarry activities above ambient noise.

EXECUTIVE SUMMARY

Oregon Department of Environmental Quality (DEQ) noise standards (OAR 340, Division 35) are used as the baseline standards for this analysis. The stricter ambient degradation standard (ambient plus 10 dBA) is used because the Howard canyon Quarry does not have an operating permit so it could be considered a ":new use" and Multnomah County has the flexibility under OAR 660, Division 16 to apply a stricter standard to address concerns raised by residents in the surrounding area.

Ambient noise levels were measured at seven residential sites surrounding the proposed quarry. Noise sources from quarry activities were measured or estimated using file data. Future noise levels are predicted and four out of seven sites meet the DEQ L50 hourly standard without mitigation measures. Proposed mitigation measures are predicted to bring noise levels below the DEQ standard for all seven sites. Truck noise is predicted to meet the DEQ L10 hourly standard for five trucks per hour or 10 round trips. Blasting noise was estimated using the Kamperman method. Only one site is predicted to exceed the standard, but it is probable that berms, barriers or a reduction in charge weight will lower noise levels below the DEQ blast noise standard of 98 dBC slow meter response time.

The DEQ hourly standards may not adequately address long-term impacts of continuous quarry activities. There is no objective livability noise standard to evaluate the nuisance factor for the surrounding residents. However, restricting operating hours may alleviate some of the nuisance factor.

Noise impacts of the proposed quarry expansion meet the State DEQ standards at 4 out of 7 sites. It may be possible to meet the standards at the other 3 sites if some advanced noise controls are designed and used. Livability at residential sites around the quarry may be affected if increases above ambient noise cannot be.

AMBIENT NOISE MEASUREMENTS

Ambient noise was measured over the operating hours of the proposed quarry expansion project at the residential sites listed below, and shown by Figure 1 attached. Also attached are Figure 2, a general area map and Figure 3 with the proposed haul truck routes.

Site-1 Residence at 39203 Howard Canyon Road, located at the end the road, south east of and within sight of the existing rock extraction site at a distance of 750 feet. Overall L50 noise level here was 40 dBA. The lowest L50 hourly noise was 39 dBA.

Site-2 Residence at 38100 Howard Canyon Road, south of the road and the proposed extraction area at a distance of 1400 feet to the proposed future rock extraction boundary. This site has a running creek along the south side of Howard Canyon Road. The microphone was placed on the uphill side of the property, near the garage, as far away from the creek as possible to limit noise from the creek. Overall L50 noise level was 64 dBA. The lowest L50 hourly noise level was 62 dBA. This site has access to Howard Canyon Creek.

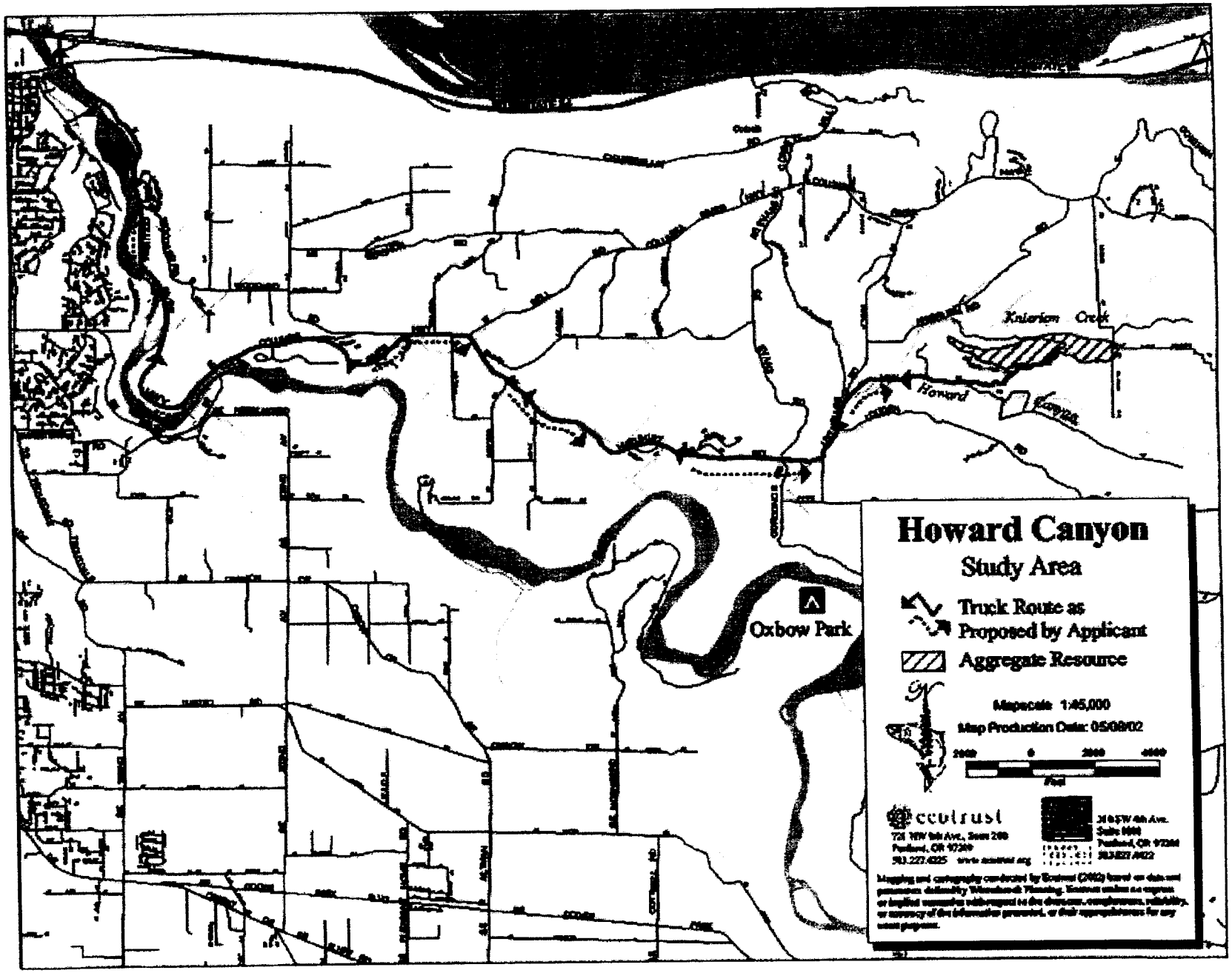
Site-3 Dawes residence at 37737 Howard Canyon Road, southwest of the proposed expansion area and below it at an approximate elevation of 500 feet, on the north side of the road. Overall L50 noise level at this site was 38 dBA and the lowest L50 was 37 dBA in the 2 PM hour.

Site-4 Residence at 38800 SE O'Regan Road, near the intersection of Louden and O'Regan Roads, southwest of the existing extraction area and within 2750 feet of the proposed rock extraction area. This location has the highest elevation, slightly above the existing extraction area at 800 feet. The overall L50 noise level was 38 dBA and the lowest L50 noise was 36 dBA in the 1 PM hour.

Site-5 Kribbs residence, a manufactured home at 210 East Knieriem Road, approximately 125 feet west of the north side rock haul road, at the foot of the hill which rises steeply to the proposed mining expansion area above. Overall noise was 40 dBA here and the lowest L50 noise level was also 40 dBA in the 2 PM hour.

Site-6 Diebert residence at 201 N.E. Salzman Road, at approximately the same elevation as the existing rock processing area, and within line-of-sight of the north side rock haul road. Overall L50 noise level was 38 dBA and the lowest L50 was also 38 dBA in the 2 PM hour.

Site-7 The Anderson residence at 37935 Howard Canyon Road, near the Site 3 residence but higher at an approximate elevation of 520 feet. This site is located at the foot of the hill leading up to the west end of the proposed rock extraction and expansion area. Overall L50 noise level was 38 at this site


Howard Canyon
Study Area
Truck Route as Proposed by Applicant
Aggregate Resource
Oxbow Park
Mapscale 1:45,000
Map Production Date: 05/09/02
ecotrust

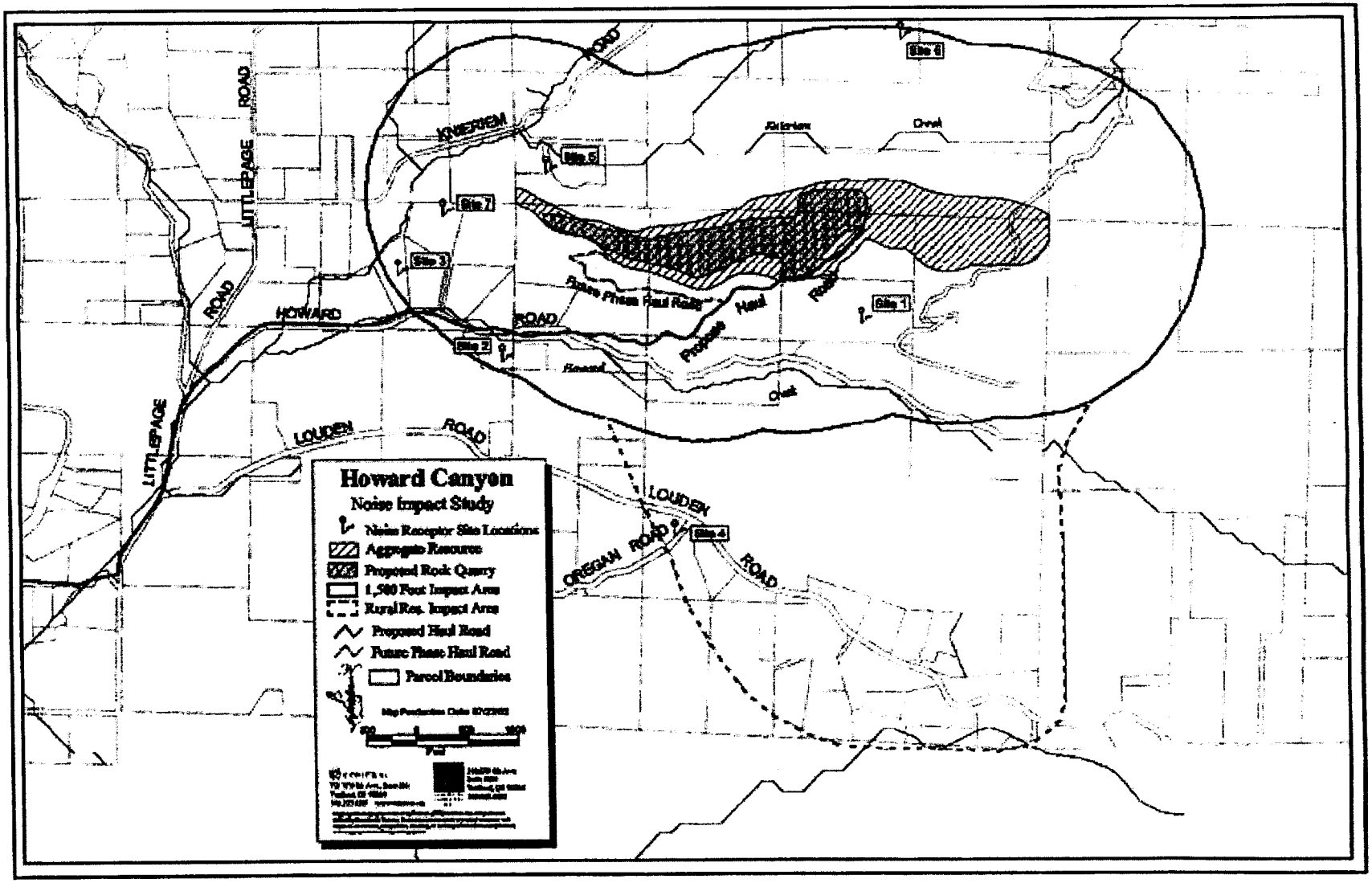

Howard Canyon
Noise Impact Study
Noise Receptor Site Locations
Aggregate Resource
Proposed Rock Quarry
1,500 Foot Impact Area
Rural Res. Impact Area
Proposed Haul Road
Future Phase Haul Road
Parcel Boundaries
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7
HOWARD ROAD
LOUDEN ROAD
LITTLEPAGE ROAD
KNUDSEN ROAD
OREGAIN ROAD
Future Phase Haul Road
Proposed Haul Road

Table 1 below shows the A-weighted residential site noise levels for the quietest hours of the proposed quarry expansion operating daytime hours of 7 a.m. to 5 p.m. The State DEQ daytime L50 ambient degradation noise standard is shown for comparison. This represents the lowest hourly L50 plus 10 dBA for the proposed operating hours.

Table 1

SITE N0.	QUIETEST HOUR L50, dBA	STATE DEQ AMBIENT NOISE CRITERIA
1	39	49
2	62	62
3	37	47
4	37	47
5	40	50
6	38	48
7	38	48

Table 1 shows that all Sites except Site 2 are below the State DEQ L50, daytime 55 dBA noise standard. Noise at Site 2 was evidently influenced by the creek near the residence. Ambient noise at the other Sites was mainly due to distant traffic, aircraft, and bird and animal noise.

There are many domestic livestock animals in this area, but they are not a serious noise source. The Interstate Rock Howard Canyon Quarry production facilities were not operating during the ambient noise measurements.

On March 28, a small contractors dump truck was seen entering the upper quarry area about 11 a.m. and it is apparent some hand loading of rock took place. This intrusion was unknown to the Interstate Rock Products dispatcher who stated that the truck should not have been there. However, examination of the ambient noise data at Site 6, showed no unusual noise excursions in the L50 and L10 noise data between 11 a.m. and 1 p.m. The peak levels were high between 10 a.m. and 12 p.m., but these short-term signals do not affect the L50 data, and they could have been farm animals. The lowest level however was chosen, and this occurred in the 2 p.m. hour when other parameters were normal.

SOURCE NOISE LEVELS

Noise sources, both existing and future were measured at the existing extraction and processing areas at the Howard Canyon Quarry. The only sources that could not be measured were jaw crusher and blasting noise. These will be estimated using consultants file data and well-known references on blasting noise. Noise sources were as follows;

1. Extraction: Samsung Model MX292/LC front loader with a 2 yard bucket loading rock into a 10 yard dump truck; measured on-site March 2, 2002; (data sheet attached).

2. Extraction: The same front loader with a hydraulic hammer attached to the front of the machine. (Same March 2, 2002 measurements; data attached).

3. Processing: Hand-operated pneumatic hammers at both the Washugal and the Howard Canyon Quarry sites, breaking rock into smaller pieces. Same March 2, 2002 measurements – data used was the sum of both hammers - attached).

4. Jaw type rock crusher breaking large rock into 3 inch minus rock; this data is an octave-band average of five jaw crushers recorded between 1988 and 1997 in the State of Oregon. Sources and noise levels listed in attached appendix A-1.

5. Rock drill used to drill holes for blasting. This data was taken from site measurements by two professional acoustical engineers and was in octave-bands. Measurements taken Feb. 17, 1998. Source levels are listed in attached appendix).

6. Haul/Dump Truck – hand measured at two main sites in the State of Oregon over the last ten years, at Pacific Rock Products, Canby. OR., and Winco Food Products Warehouse, Salem, OR. Source levels listed in appendix.

Noise sources were measured using a precision Type 1 sound level meter driving a computer based octave-band analysis program. This was done to provide octave band frequency data which will be used to predict future noise levels at the residential sites listed above. Handheld noise data was also recorded using a Bruel & Kjaer Model 2231

Type 1 precision sound level meter. Statistical levels in dBA were also recorded for some sources using a Larson Davis-Labs Model 700 noise analyzer. The acoustic measurement system was calibrated using a Bruel & Kjaer Model 4230, 94 decibel, 1000 Hz field calibrator attached to the microphone of the sound level meters.

The computer generated data sheets are attached in the appendix, and the A-weighted data is listed below for each source at a distance of 50 feet;

Source	Noise Level, dBA
Front Loader & Truck	96 dBA at 50 Feet, L1
Mobile Hydraulic Hammer	89 dBA at 50 Feet, L10
Hand Hydraulic Hammers	86 dBA at 50 Feet
Jaw Crusher	87 dBA at 50 Feet
Rock Drill	91 dBA at 50 Feet
Haul/Dump Truck	82 dBA at 50 feet at 35 mph

Octave-band noise levels for all of the above sources except haul trucks were used to generate future equipment operating noise levels at all sites.

NOISE STANDARDS AND CRITERIA

The noise standard that applies to this project is the State Department of Environmental Quality noise standard OAR 340-35. Noise levels for this standard are listed below in Table 2. They are never to be exceeded.

Table 2

DEQ Noise Standards, dBA

Time	L1	L10	L50
0700 to 2200 (Daytime)	**75**	**60**	**55**
2200 to 0700 (Nighttime)	**60**	**55**	**50**

Table 3 below compares the allowable daytime DEQ L10 and L50 noise standards, with the ambient-plus-10 dBA ambient degradation standards. Whenever the ambient-+-10 dBA level exceeds the maximum allowable l10 and L50 DEQ level;, it must be dropped back to that level. The only exception is when the ambient noise is already above the DEQ daytime standard such as at Site 2.

Table 3

DEQ Daytime Noise Standards at Sites

Site	L10 Std	L10 Amb+10	L50 Std	L50 Amb+10
1	60	56	55	49
2	60	73(63)	55	72(62)
3	60	55	55	47
4	60	56	55	47
5	60	52	55	50
6	60	52	55	48
7	60	51	55	48

Note: Ambient noise at Site 2 is 63 L10 and 62 L50 noise level.

These are called the statistical noise levels, are related to time in that the number after the letter refers to percent of a standard measurement hour. The L1 refers to 1 percent of a standard measurement hour or 36 seconds; the L10 refers to 10 percent or 6 minutes of any measurement hour; and the L50 refers to 50 percent or 30 minutes of an hour.

The noise levels in the hour are cumulative in that they do not have to occur together. The standard is an hourly standard, and the ambient noise data attached is recorded in hourly increments. The L1 is heavily influenced by very short time events (impact sounds) such as car door slams or bird calls, and is therefore not used for normal environmental noise.

The L50 is the lowest level standard, and if it can be met, the L10 is also normally met. The L10 level would be influenced by low volume truck traffic on rural roads such as Howard Canyon Road. The L50 would be influenced by longer term noises such as processing noise at a rock quarry.

For this project and its expansion into an unused area for more rock production, another DEQ standard applies. This is called the "ambient degradation clause" of the standard. This clause states that the lowest hourly existing ambient noise cannot be exceeded by more than 10 dBA.

Thus, the ambient levels listed in Tables 1 above are increased by 10 dBA for future rock processing and extraction activities. This would include truck traffic on the haul roads out of the quarry area.

FUTURE NOISE LEVELS

Future processing and extraction noise levels were predicted using a popular computer sound propagation program called "Noisecalc" also known as the "New York Program" developed by the State of New York Department of the Environment. The program takes into account source octave-band levels, inverse square law spreading, atmospheric attenuation, distance between sources and receivers, and the elevation of each. Calibration of the program has shown that it is accurate within 2 dBA of actual noise levels.

The site map shown by Figure 1 (attached) shows the ambient noise measurement sites which are also the sites for future noise prediction. Table 4 below shows the noise sites with the distances to the closest future rock extraction and processing locations. It is assumed that rock extraction activities such as overburden removal, blasting and rock extraction will take place at a setback distance of 50 feet from the property line shown in yellow. Future rock processing activities such as crushing are assumed to take place where they do now, in the sheltered area at the top of the eastern section of activity. This area is protected by a rock wall 25 to 30 feet high around three sides of the area. The processing area does not however have this high barrier protection to the northeast. This will be discussed more under the "recommendations" section ahead in this report.

Processing in this area in the future would require that either long rock conveyors or haul trucks would be used to bring pit-run rock to the processing area.

Table 4
Processing and Extraction Distances

Site	Processing Distance	Future Extraction Distance
1	1025	1025
2	3625	1400
3	4600	1375
4	3550	2750
5	3100	400
6	2075	1565
7	4065	770

Truck Noise

Truck noise was calculated by hand using the dBA level because there are reliable octave-band levels for these heavy vehicles when moving at a speed of 35 mph, 50 feet from a residence. A simple equation shown below for each hourly truck volume was used;

$$DL = \frac{(60 \text{ minutes} \times (\text{Percentile}) \times S}{T \times C}$$

Where DL = the distance to the moving truck where noise is just equal to the percentile (L10, L50 etc); percentile is in the decimal form of percent (L10 = 0.1); and T = hourly feet per minute. The DL distance is then related to the **reference truck noise level of 82 dBA at 35 mph at 50 feet** using the inverse square law of acoustics, or dBA = 20 Log (base 10) x ratio of the distances.* The DL distance is good for any site location as long as the site has a clear view of the truck in both directions and there are no unusual conditions such as a background noise higher than the truck statistical noise level.

According to the project traffic engineer, the maximum hourly truck volume that can be expected with the higher cubic yard rock production in a future year is 40 trucks per day or approximately 5 trucks per hour. This is the truck volume T used in the noise equation above. It can be assumed that truck noise level is approximately the same coming or going, or within 2 dBA, and the statistical nature of traffic noise tends to even out these differences. Calculated truck L10 noise level is 48 dBA for each site and is compared with the State DEQ L10 ambient degradation noise level for each site in Table 5 below;

The DL distance for the L10 level is 1848 feet, and the adjusted noise level is 51 dBA.

If trucks travel faster than 35 mph, or are closer than 50 feet from the roadway, noise will increase. The calculation assumes a level grade, and a rising grade will increase noise. If the distance decreases from 50 feet to 25 feet, noise would increase 6 dBA.

- Footnote: Calculated from Federal Highway Program Manual PPM 7-7-3, August 1982, Transmittal 348; dBA = 24.6 Log Speed (km/hr) + 38.5. This formula was checked and found to be in close agreement with actual truck noise measurements made by this author.

Table 5
L10 Truck Noise vs DEQ Standard

Site	L10 Truck Noise dBA	DEQ L10 Standard dBA
1	51	56
2	51	63
3	51	55
4	51	56
5	51	52
6	51	52
7	51	51

The truck noise data in Table 5 above meets the State DEQ L10 noise standard for five trucks per hour or 10 round trips. The L10 noise standard at each site is the measured ambient L10 level plus 10 dBA. At Site 2, the standard is the actual measured L10 level because it is higher than the State DEQ standard daytime L10 of 60 dBA. If the truck volume decreases from 5 trucks per hour to 2 per hour, L10 truck noise would decrease to 43 dBA for a reduction of 8 dBA.

The use of Jacobs (Jake) engine brakes on trucks can lead to noise levels 20 dBA over normal transmission brake-down on down-hill runs. Using the new engine mufflers specifically designed for Jacobs brake operation can reduce this increase to 10 dBA. Down-hill runs with loaded trucks may therefore increase noise for short periods of time, usually less than 20 seconds, by 10 to 20 dBA at some sites nearest the haul roads.

Table 5 below shows predicted noise levels for the six sites for both processing and extraction noise. Noise data for a hydraulic rock drill was used to predict rock drill noise. This unit is quieter than pneumatic types. The L1 statistical noise level of 89 dBA was used for rock drill noise calculation as a worse case condition. (Since the rock drill runs for more than 30 minutes at a time, use of the L50 drill noise level of 87 dBA would result in a drill noise level 2 dBA less than that shown in Table 6 below). Even though excavation noise is almost as high as rock drill noise, drill noise could last from one to three days depending on the blast conditions. Therefore the rock drill becomes important as a semi-continuous noise source for which there are mitigation measures.

Table 6

Predicted L50 Noise Levels For Sources Compared to DEQ Standard

SITE	HAMMER NOISE	EXCAVATION NOISE	JAW CRUSHER	ROCK DRILL	TOTAL NOISE	DEQ AMB STANDARD
1	34	47	42	48	51	49
2	20	40	31	42	44	62
3	17	39	28	41	43	47
4	21	39	32	23	40	47
5	21	49	32	50	53	50
6	26	18	39	47	48	48
7	17	42	29	43	47	48

Total noise meets the State DEQ ambient degradation noise standard at all Sites except Sites 1 and 5. Noise at Site 6 equals the noise standard. Barriers were located 50 feet from the equipment which is a common measurement distance.

Because rock drill noise is relatively short term (two to 3 days twice a year, when compared to the daily rock processing, it is interesting to compare total noise without the rock drill. Table 7 below does this.

Table 7

Predicted L50 Noise Levels For Sources Compared to DEQ Standard

Without Rock Drill Noise

SITE	HAMMER NOISE	EXCAVATION NOISE	JAW CRUSHER	TOTAL NOISE	DEQ AMB STANDARD
1	34	47	42	48	49
2	20	40	31	41	62
3	17	39	28	39	47
4	21	39	32	40	47
5	21	49	32	49	50
6	26	18	39	39	48
7	17	42	29	42	48

Table 7 above shows that normal processing and excavation noise without the rock drill decreases noise by a considerable amount at all sites except Site 4 where noise does not change. At the other sites, noise decreases between 3 and 9 dBA which is a significant change. Total future noise in this case still meets the DEQ standard.

Equipment elevations used for noise calculations were 4 feet above grade for the hand-held pneumatic hammers, and 8 feet for the loader-mounted front excavator. The jaw crusher height was assumed to be 6 feet above grade. For excavation, the nearest point to a site 50 feet inside the yellow mining line shown on the map of Figure 2 was used. (The applicant proposes a 100 foot setback distance, but the 50 feet used in this report is conservative). It was also assumed that a D8 Caterpillar bulldozer with ripper attached would be used to remove overburden and push it up to build a berm 10 feet high all around the yellow mining line at the crest of the hill. This berm building operation is exempted from the State DEQ noise standard, and not calculations were done for this machine. It should however be fitted with a "residential" quality muffler, and its operation should be limited to the daytime hours between 7 a.m. and 5 p.m. (See section on Mitigation Measures).

For Sites 1, 5 and 6 where predicted future noise lies over or at the standard, it is probable that operating distances could be increased or that berm elevations could be increased enough to place the site into compliance with the controlling source. Other suggested controls are listed ahead in this report.

Excavator noise caused by the dumping of large rock into dump trucks is a difficult source to control because of the equipment height. This as measured with a noise analyzer to be 89 dBA at 50 feet. Other than those comments listed in item 8 under Noise Mitigation ahead, there are no feasible noise controls available in this writes experience.

Blasting Noise Impacts

Blasting noise was estimated using George W. Kampermans' study of 1980 called "Human Response to Blasting Noise and Vibration" presented at InterNoise 80 in Miami, Florida in December 1980. This method is widely accepted by acoustical engineers as a very good noise predictor, and it can be used also for sonic booms, showing that it correlates well with the low frequency "boom" sounds of blasting. The method calculates the scaled distance which is the distance in feet to the receiver, divided by the square root of the average explosive charge weight per delay, or per hole. The charge weight per delay is the total charge weight divided by the number of holes. For blasting in rock quarries in Oregon, an average charge weight of 150 pounds per hole of ANFO fertilizer explosive is used for blast areas near residences. Using this charge weight and the distances between each site and the extraction area with a minimum 50 feet setback from the yellow mining line of Figure 2, the values of scaled distance were calculated and the noise level in dBC (decibels "C" weighting network") was read from Kampermans' graph. A copy of this graph is included in the appendix of this report. Table 8 below shows the data and the dBC noise level compared to the State DEQ blast noise standard;

Table 8
Blasting Estimates Per Kamperman

SITE NO.	DISTANCE FEET	SCALED DISTANCE	dBC	STATE DEQ BLAST STANDARD dBC
1	575	47	96	98
2	1400	114	83	98
3	1375	112	82	98
4	2750	224	71	98
5	450	37	99	98
6	1565	128	84	98
7	770	63	94	98

The dBC blast noise level is different (usually higher) than the environmental dBA levels described throughout this report, and cannot be compared or converted directly without knowing the frequency spectrum of each noise. This is why blast noise cannot be compared with "a"-weighted ambient noise directly.

Table 8 above shows that only one site (Site 5) lies over the State DEQ blast noise standard of 98 dBC. These estimates are for straight line-of-sight between the blast center and the receiver. It is probable that berms or barriers, or a reduction in charge weight might lower radiated blast noise levels. Increasing the number of holes while maintaining the total charge weight of explosive would also lower noise by decreasing the charge weight per hole. The U.S. Bureau of Mines has determined that a time delay between holes of approximately 17 milliseconds is ideal for most noise sensitive cases.

Livability Noise Criteria

There are no livability noise criteria in existence in our country today. It is this consultants belief that livability in relation to the noise environment should be tied to increases above ambient noise.

NOISE IMPACT CLASSIFICATION

Decibel Increase	Probable Impact
0	None
1 to 5	Minimal - Few Complaints
5 to 10	Moderate – Some Complaints
10 to 15	Major – Threats of Legal Action

Table 9 below compares the lowest L50 ambient noise during proposed quarry operating hours with the predicted levels of total noise. Truck noise is listed separately in Table 9 because it is an L10 noise level;

Table 9

Lowest Ambient Noise Compared to Total Quarry Noise

SITE NO.	QUIETEST HOUR L50, dBA	TOTAL QUARRY NOISE	INCREASE	NOISE IMPACT
1	39	51	12	MAJOR
2	62	44	0	NONE
3	37	43	6	MODERATE
4	37	40	3	MINIMAL
5	40	53	13	MAJOR
6	38	48	10	MODERATE
7	38	47	9	MODERATE

Table 9 above shows serious noise impacts at Sites 1 and 5, with moderate impacts at Sites 3, 6 and 7. These classifications are based on increases above existing ambient noise and not on the DEQ standards. The State DEQ determined. when they wrote their noise standard, that they would allow an increase of 10 dBA above ambient noise for properties to be developed that had not been used before for the particular land use. Some persons feel that the 10 dBA increase is too high, while others do not.

The DEQ staff at the time explained the allowable increase was to protect the environment adequately while not stifling development altogether. They believed that most people could tolerate an increase of 10 dBA, at least during daytime hours, as most noisy businesses do not operate at night. For those that do operate at night, it is necessary to get them to shut down long enough to measure the absolute background noise at the receiver locations.

It should be noted here that just because a noise meets the DEQ standard does not necessarily mean that a resident will not hear the noise. Audibility depends on background noise conditions, wind velocity and direction. Wind in the trees can tend to mask downwind sound reinforcement to lesson its effect. Examination of the statistical wind data from the NOAA at the Portland airport shows a mean annual wind speed and direction of about 8 mph from the southwest. The meteorological data for 2001 (data sheets attached) show that an easterly wind shows up in November through March, and shifts to the south-west for the months of April through October. The 2 minute data shows approximately the same wind directions at higher wind speeds.

It is probable that at some time, quarry activities and wind direction will coincide and cause some downwind sound reinforcement. However, this is highly variable, and noise standards cannot be written to include wind effects. They definitely can affect livability however.

The existing State DEQ hourly noise standard may not adequately predict resident's annoyance for continuous quarry production activities spread out over a ten-hour day. While there is no subjective-to-objective way to predict annoyance based on hourly L50 predicted noise levels, one can look at the hourly Leq levels. (The Leq is used by the FAA and USHUD to calculate the 24 hour Ldn or DNL level to regulate noise for airports and HUD sponsored living units. This unit however tends to smooth over the hourly variations frequently seen near these sites). The measured ambient lowest hourly L50 levels at the seven sites are lower than the hourly Leq energy average levels except at Site 2 where they are equal. However, adding 10 dBA to the lowest L50 levels per the DEQ ambient degradation standard brings the L50 levels above each hourly Leq. The writer believes that the hourly L50 level is the better method to compare predicted future noise with ambient noise as explained above.

NOISE MITIGATION METHODS

It is possible that modifications to normal quarry excavation and blasting conditions could serve to lower radiated noise. Table 6 above shows that the rock drill controls the noise environment at Sites 1, 5 and 6 when it is in use for a possible two to three days of drilling. (A hydraulic operated rock drill with an integral power supply was used for the noise source within 50 feet of the berm at the crest of the hill). Hydraulic rock drill data is included in the noise source section of the attached appendix. Recommendations for noise mitigation for this project are summarized below;

1. Require blasters and drillers to use hydraulic rock drills. Install a vinyl plastic 1-psf noise barrier, or a straw bale barrier around the rock drill when operating near Sites 1, 5 and 6. This barrier should be at least 2 feet higher than the top of the drill.

2. Require blasters to monitor noise at several sites during the first blast events. Make adjustments to blasting parameters such as total charge weight, number of holes and stemming as necessary to meet the DEQ blast noise standard or reduce annoyance. Advance notice of blast events should be publicized to the surrounding community.

3. Require applicant to maintain a 25 to 30 foot rock wall enclosing the processing area on three sides.

4. Require applicant to push up overburden to establish a 10 foot high berm at the crest of the hill at each new excavation location. (Machine noise due to building of berms is excluded from the DEQ noise standards). It should also be short term noise.

5. Require applicant to use conveyor belts to convey excavated rock to the present easterly processing area if the excavation process for crushed rock becomes continuous on a daily 8 to 10 hour basis. (instead of noisier haul trucks - noise reduction in the L10 could be 6 dBA quieter using conveyors). Conveyors will not be required for excavation of the larger decorative boulders used at this quarry. If conveyors are used, enclose conveyor elevation change-over transfer points with 20 gauge steel enclosure lined with 1" inch fiberglass panels.

6. Prohibit the use of engine "jake" brakes at any point on the haul roads except in the case of dire emergency to avoid accidents. If these brakes must be used due the extreme down grade of the haul road, require the installation of the special silencer called the "Donaldson Silent Partner" developed for "jake" brake noise reduction. See cut sheet attached. (Air Flow Systems Inc. of Milwaukie, OR., see item 9 below).

7. Require the applicant to hire a qualified registered acoustical engineer to conduct semi-annual noise measurements for the first year, at three of the closest sites after startup of the properly permitted quarry operation. After the first year, require annual measurements at the same three sites for a period of three years. The engineers' report should be presented to the Multnomah County Planning Department for approval.

8. There are no simple noise reduction techniques for the hand-held pneumatic hammers presently being used to break rock, or for the hydraulic hammer mounted at the front of the excavator. The 25 to 30 foot high rock walls around the processing area should serve to reduce hand-operated processing a significant amount, to the levels shown in Table 6. The hydraulic excavator bucket mounted at the front of the large excavator machine is more difficult to control. Berms and barriers can be effective however the required height may make them infeasible. If jaw crusher noise is annoying at Sites 1 and 6, it should be feasible to surround the crusher with 1-psf vinyl plastic panel barriers supported by a suitable steel framework. Such a barrier should extend at least 2 feet over the highest point of the crusher.

9. The Caterpillar dozer used for pushing up berms and removing overburden should be fitted with a "residential" quality exhaust muffler available from Air Flow Systems Inc. of Milwaukie, OR at 503-659-9120. This muffler should yield about 8 decibels more reduction for the low frequency exhaust component, and about 5 dBA noise reduction over the typical industrial grade muffler normally supplied with these diesel machines. These mufflers are relatively inexpensive.

10. To improve livability, operating hours should be limited to 8 a.m. to 5 p.m., with no operation between May and October on Saturdays or Sundays.

NOISE WITH ROCK DRILL MITIGATION

Total noise with use of a straw bale temporary noise barrier shows a minimum reduction of 10 dBA for the rock drill The results of this reduction are shown below in Table 10;

Table 10

Predicted L50 Noise Levels For Sources Compared to DEQ Standard With Hydraulic Rock Drill & Close Barrier

SITE	HAMMER NOISE	EXCAVATION NOISE	JAW CRUSHER	ROCK DRILL	TOTAL NOISE	DEQ AMB STANDARD
1	34	47	42	38	48	49
2	20	40	31	32	41	62
3	17	39	28	31	40	47
4	21	39	32	13	40	47
5	21	49	32	40	49	50
6	26	18	39	37	41	48
7	17	42	29	33	43	48

Table 10 shows that total noise now meets the DEQ ambient noise standard at all Sites. Since no excess attenuation due to ground cover or forest land, where available was used in the future noise calculations, it is likely that total noise will be about 5 dBA less at some sites depending on the distance between the sources and receivers. Ground cover was not used in order to be conservative in noise estimates. Table 11 below shows total quarry noise with the quieter hydraulic rock drill compared to the quietest hour background during daylight operating hours for a new assessment of livability;

Table 11
Lowest Ambient Noise Compared to Total Quarry Noise
With Hydraulic Rock Drill

SITE NO.	QUIETEST HOUR L50, dBA	TOTAL QUARRY NOISE	INCREASE	NOISE IMPACT
1	39	48	9	MODERATE
2	62	41	0	NONE
3	37	40	3	MINIMAL
4	37	40	3	MINIMAL
5	40	49	9	MODERATE
6	38	41	3	MINIMAL
7	38	43	5	MINIMAL

The table above shows changes in the expected annoyance from Major to moderate at Sites 1 and 5; and to Minimal at Sites 3, 6 and 7, with no Major impacts at any Site. This is a major improvement and should help to limit annoyance.

Respectively Submitted April 8, 2002

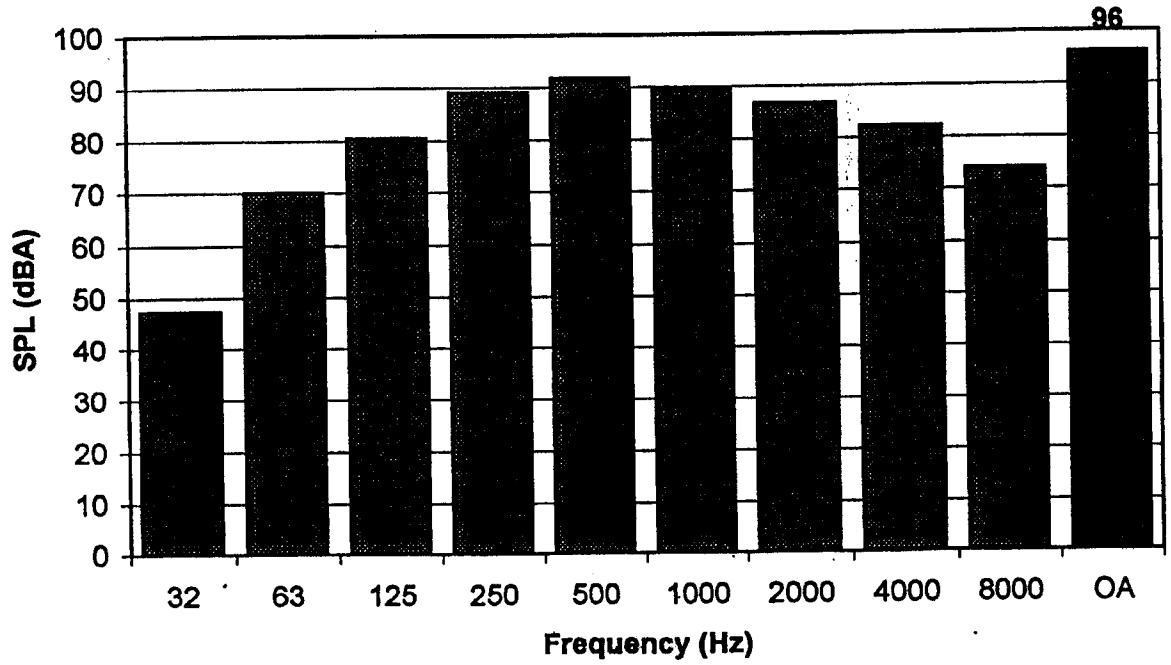
Albert G. Duble, P.E.
Acoustical Engineer
Mem. INCE

SPL Measurement Data

Subject: L_{01} - Dump truck being loaded at Corbett Quarry - 1st dump
Project: 134011
Date Measured: Oct-25-2001
WAV File: 130011-1.WAV
Msmt.Distance: 50 ft to center of excavator/rock hammer head
Description: Dump truck being loaded with rock from side by front end loader at Corbett Quarry. Measured at 50 ft to side of line between loader and truck. This spectrum represents the first load when the truck is empty Derived from measured WAV file and scaled to L_{01} SPL
Averaging Type: Linear
Freq. Weighting: A

Octave Band SPL Data										
Frequency (Hz)	32	63	125	250	500	1000	2000	4000	8000	OA
SPL @ 50 ft (dBA)	47.3	70.0	80.4	89.2	91.8	89.4	86.7	82.1	73.9	96.0
SPL @ 50 ft (dB-Lin)	86.7	96.2	96.5	97.8	95.0	89.4	85.5	81.1	75.0	102.9

SPL Spectrum at 50 ft



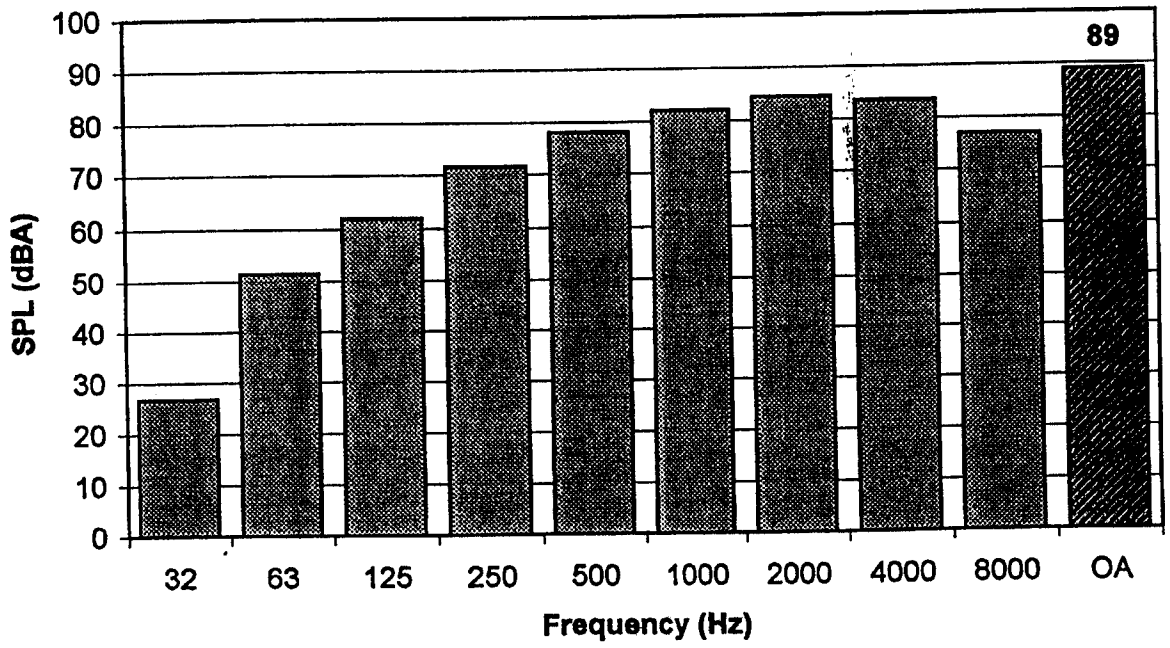
SPL Measurement Data

Subject: L_{10} - Rock Breaker Rammer 10X on Samsung MX292 Tracked Excavator
Project: 134011
Date Measured: Oct-25-2001
WAV File: 130011-1.WAV
Msmt.Distance: 50 ft to center of excavator/rock hammer head
Description: Rock breaker head mounted on tracked excavator used to break rock at Corbett Quarry. Measured at 50 ft to side of line between excavator and head. This spectrum represents individual impacts (L_{10} SPL) Derived from spectra of individual impacts scaled to L_{10} SPL
Averaging Type: Linear
Freq. Weighting: A

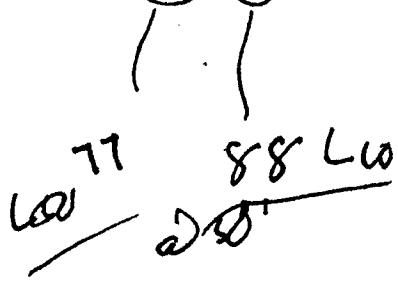
Octave Band SPL Data

Frequency (Hz)	32	63	125	250	500	1000	2000	4000	8000	OA
SPL @ 50 ft (dBA)	26.8	51.4	61.9	71.5	78.1	82.0	84.5	83.5	76.9	89.0
SPL @ 50 ft (dB-Lin)	66.2	77.6	78.0	80.1	81.3	82.0	83.3	82.5	78.0	89.9

SPL Spectrum at 50 ft



Summary of Statistical SPL Data Measured at Corbett Quarry @ 50 ft distance							
Rammer 10X Rock Breaker on Samsung MX292 Tracked Excavator							
	Statistical SPL (dBA)						
Measurement Details	L_{50}	L_{10}	L_{01}				
Measured 10/25/2001	77.5	89.0	93.0				
Measured 03/02/2002	77.0	86.0	90.5				



Summary of SPL Spectra from Jackhammers Measured at Corbett Quarry @ 50 ft distance											
	Freq. (Hz)	31.5	63	125	250	500	1000	2000	4000	8000	OA
Newer unit (#1) 03/02/2002	SPL (dB)	34.9	48.1	59.8	75.6	72.0	74.6	73.5	76.3	77.2	83.0
Older unit (#2) 03/02/2002	SPL (dB)	44.5	54.1	63.1	78.3	75.6	77.0	77.9	81.6	81.6	87.0
Unit Measured 06/29/2001	SPL (dB)	37.8	49.5	67.0	81.1	70.8	78.6	78.9	79.7	80.6	87.0
Energy Average		40.9	51.4	64.3	78.9	73.3	77.0	77.3	79.6	80.1	86.0

APPENDIX

A-1

JAW CRUSHER NOISE DATA

SOURCE	FEET	dBA	31	63	125	250	500	1000	2000	4000	8000	16000
Riverbend S & G ;3-97	50	82	82	80	80	77	80	92	84	82	77	65
Warm Springs 4-91	50	82		81	81	83	84	89	85	81	62	
Bayview Transit 5-88	50	89	80	84	86	82	84	84	83	78	70	57
Brock Pit Scio 6-95	50	87	78	82	85	85	85	82	80	74	68	58
Johnson & Sons-Seaside 9-92	50	90	84	78	79	77	77	79	84	85	83	75
Energy Average	50	87	81	81	83	82	83	85	83	87	77	69

ROCK DRILL NOISE DATA - PNEUMATIC

SOURCE	FEET	dBA	31	63	125	250	500	1000	2000	4000	8000	16000
Ingersol-Rand 1-90	50	91	84	78	79	77	77	79	84	85	83	75
G & G Rock-Scio 1-89	50	91		912	90	82	86	85	83	84	82	
Starr Quarry-Amity 6-94	50	89	80	84	85	83	83	84	84	79	70	56
Johnson & Sons Seaside 9-92	50	93	85	81	90	87	88	90	86	80	69	59
Energy Average	50	91	83	92	88	84	85	86	84	83	80	70

APPENDIX A-2

HYDRAULIC ROCK DRILL NOISE DATA

Model C-700 Chicago Pneumatic Co. – Recorded Feb 7, by Mr. Bill Holliday, Registered Acoustical Engineer, at Parkin Quarry (West Side Rock);
Sound Level Meter: Type I Larson-Davis Labs with octave-band filter attachment.

Frequency:	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dBA**
Noise Level Decibels	**73**	**79**	**84**	**80**	**81**	**83**	**80**	**72**	**68**	**89**