Submission to the Colorado Oil and Gas Conservation Commission

OIL AND GAS ACCOUNTABILITY PROJECT'S AND SAN JUAN CITIZENS ALLIANCE'S RECOMMENDED CHANGES TO COGCC'S PROPOSED NOISE RULE (RULE 802)

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Table of Contents

1.0 COGCC'S UNIQUE RESPONSIBILITY TO REGULATE NOISE

The Colorado Oil and Gas Conservation Commission (COGCC), in addition to promoting the efficient extraction of the state's oil and gas resources, has a responsibility for protecting the public health, safety and welfare of the citizens of this state.

Noise is an issue that can create health problems for people – both directly, e.g., can cause headaches, hypertension, etc., and indirectly, e.g., the annoyance of a particular noise source can create stress, which can lead to or exacerbate health problems.

In most states, local governments have the ability to regulate noise, regardless of its source. This allows municipalities and counties to develop noise-related ordinances to ensure acceptable noise levels in commercial, residential and rural neighborhoods. In oil and gas producing regions, these local ordinances often include restrictions on noise emanating from oil and gas operations. Appendix 1 provides an example of a local ordinance specific to noise from oil and gas facilities for the City of Longbeach, California. (Note that this municipality not only regulates noise from long-term, stationary oil and gas facilities, but also from drilling rigs).

In Colorado, however, the COGCC has the responsibility for regulating noise from oil and gas facilities. This places a great responsibility on the COGCC to ensure that rules are in place to protect citizens exposed to oil and gas noise.

The COGCC's responsibility is a challenging one for a couple of reasons: First, one of the distinguishing characteristics of oil and gas facilities is that unlike other industrial operations a typical oil and gas facility operates 24 hours-a-day, 7 days-a-week. Many compressors and pumpjacks run continuously; if they are not continuous, they turn off and on when they need to – during the day or night. Other industrial operations that take place in rural environments (e.g., gravel pit operations) tend to shut down at night.

Second, the current framework for the proposed rule is basically a "one-size fits all" standard that lumps together residential, rural and agricultural areas into a single category. In reality, the typical ambient noise levels in these types of areas vary considerably. In many rural settings noise levels may be quite low during the day, and at night the noise in rural areas is often extremely low. In residential and some rural settings the ambient noise level may be quite high during the day (due to traffic or the operation of agricultural machinery) but at night, because most activity slows or stops, the ambient noise levels decrease. Finding a standard that is protective of all of these environments is a major challenge that is before the COGCC Commissioners.

The Oil and Gas Accountability Project and San Juan Citizens Alliance, in consultation with citizens and organizations from across the state, have developed some alternative provisions to those in the proposed noise rule. While there are many aspects of the proposed rule that we agreed with, there were certain issues the Noise Stakeholder Group was unable to achieve consensus on. Section 2 provides a summary of our recommended changes to the proposed rule. We believe these changes effectively address some of the challenging issues that confront the Commission.

2.0 RECOMMENDATIONS

RECOMMENDATION 1. Adopt a residential/rural/agricultural standard of 45 dbA

Proposed new language for the noise rule (changes are underlined):

802. NOISE ABATEMENT

c. In the hours between 7:00 a.m. and the next 7:00 p.m. the noise levels permitted below may be increased ten (10) db(a) for a period not to exceed fifteen (15) minutes in any one (1) hour period. The allowable noise level for periodic, impulsive or shrill noises is reduced by five (5) dB(A) from the levels shown.

Zone	**7:00 am to 7:00pm**	**7:00 pm to next 7:00 am**
Residential/AGRICULTURAL/RURAL	55 db(A)	45 db(A)

The current residential/rural/agricultural standard in the proposed noise rule is 50 dBA (nighttime). According to the World Health Organization (WHO) this level is not protective of human health and wellbeing. WHO recommends a 16-hour daytime L_{EQ} (equivalent continuous sound pressure level)[1] of 55 dBA (daytime) and a 45 dBA (nighttime) to prevent "annoyance," and a lower daytime L_{EQ} of 50 dBA and a nighttime of 40 dBA to prevent "serious annoyance."[2]

We recommend that oil and gas operations in Colorado be required to meet a noise standard of 45 dBA (nighttime) in residential/rural/agricultural areas, and a daytime standard of 55 dBA. We believe these levels are necessary to prevent annoyance and help to better protect the health and wellbeing of many of the people who live in communities or residences that are located close to oil and gas facilities in Colorado.

According to a Colorado-based noise consultant who made a presentation at one of the Noise Stakeholder Group meetings, ambient noise levels in residential areas are frequently as low as 35 dBA during the nighttime, and are occasionally lower.[3] In these situations, if oil and gas facilities are allowed to emit noise at 45 dBA, the noise will be perceived by many as being twice as loud as the ambient noise in the area. (See Appendix 1.) That is a significant impact on the lives of the people living in those areas.

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[1] In most noise environments sound is not constant, and so a single reading cannot possible represent the noise environment. The Leq is a widely used method of measuring noise over a period of time and deriving a number that represents the noise for that period of time. In other words, the Leq is the level that, had it been a steady level during the measurement period, would represent the amount of energy present in the measured, fluctuating sound pressure level. Leq is not a simple average of the values. Louder noises are given more weight in this method. For example, if during a one-hour period the sound level was 80 dbA for 1/2 hour and 70 dBA for the other half hour the Leq is not 75 dBA, but rather, 77.4 dBA. LAeq means that the A-weighted scale has been used.

[2] Berglund, B., Lindvall, T. and Schwela, D. 1999. *Guidelines for Community Noise*. World Health Organization. p. xiv.

[3] McGregor, H.N. (Engineering Dynamics, Inc., Englewood, CO). *Propagation of Noise from Gas Compression Facilities Located in Mountainous Terrain.* (Handout at the first COGCC Noise Stakeholder Meeting.)

Ideally, we would be advocating for an even lower allowable decibel level of 40 dBA, such as that applied in rural oil and gas producing areas of Alberta, since 40 dBA would be much more protective for residents living in areas that have a nighttime ambient level of 35 dBA. But considering that the Noise Stakeholder Group agreed that the residential standard would also be applied to rural and agricultural areas, an allowable decibel level of 45 dBA for this zone is a better reflection of the range of ambient nighttime levels likely to be experienced in rural, agricultural and residential areas at night.

There may be some concern expressed by the oil and gas industry that it will be too costly if companies are required to mitigate all operations so that noise measured 350 feet from the source is 45 dBA. The way the proposed rule is written, however, it is unlikely that they would have to meet a 45 dBA standard in all or even most situations.

Section c.(5) of the proposed rule says that, "*the existing ambient noise level from all other sources in the encompassing environment at the time and place of such sound level measurement shall be considered to determine the contribution to the sound level by the oil and gas operation(s).*"

In other words, if an oil or gas facility is located in an area with high ambient noise, it is unlikely that they will have to quiet the facility to 45 dBA. For example, if the operation is located next to a highway, the noise from the highway would be part of the ambient noise level, and factored into the acceptable noise level for that oil and gas facility. (How ambient noise is factored into the allowable noise level from oil and gas facilities is addressed in our Recommendation 2.)

Moreover, the COGCC rule is complaint-driven, so if companies are operating in areas where the ambient noise is higher than 45 dBA, the contribution of noise from their facilities may have little or no impact on nearby residents; thus, no complaints will be generated. If companies are operating in areas where the ambient noise level is 45 dBA or lower, however, then oil and gas operators should be required to mitigate their noise to this level, rather than the proposed 50 dBA.

Noise standards of 45 dBA L_{EQ} (nighttime) or lower are used in many jurisdictions that have oil and gas operations.

> **Alberta, Canada:** Alberta is a major oil and natural gas producing province in Canada. In Alberta, the Energy and Utilities Board has the responsibility for regulating noise from oil and gas operations. The EUB has produced what may be the most comprehensive noise regulations for the oil and gas industry across North America. The EUB essentially has a sliding scale noise standard whereby acceptable noise levels vary with the ambient noise.[4] For example, if a citizen lives in an area where ambient noise is low (e.g., where housing density and traffic noise are low), then the oil and gas operator must ensure that noise reaching the receptor is no louder than 40 dBA. In some instances, if the ambient noise is very low (e.g., 30 dBA), companies may be required to mitigate noise to even lower levels (e.g., 35 dBA).

[4] Alberta Energy and Utilities Board (EUB). November, 1999. *Noise Control Directive User Guide*. (Guide 38). p. 16.

As ambient noise conditions increase, the allowable noise level increases. The highest allowable level in a residential neighborhood is 56 dBA at night. This noise level applies when there are more than 160 dwellings in a quarter-mile radius, and there is a major traffic source (road, rail, air) within 30 m (90 feet) of any of the dwellings. (See Appendix 3 for a complete table of Alberta's allowable noise levels for oil and gas operations.)

World Bank: For onshore sites, the maximum acceptable noise levels recorded at receptors or the edges of a property boundary, and on an average hourly basis are 55 dB(A) and 45 dB(A) for day and night, respectively. These levels apply to residential, educational and institutional areas.[5]

Sacramento County, CA: Sacramento County is a significant producer of dry natural gas in California.[6] The allowable noise level, according to the Sacramento County General Plan, is 50 dBA L50 (daytime) and 45 dBA L50 (nighttime), measured at residential properties.[7]

City of Longbeach, CA: The allowable noise level in residential areas is 45 dBA (nighttime).[8]

Examples of oil- and gas-related noise requirements of 45 dBA or lower.

	Measurement location	**Nighttime dBA level**
World Bank – New oil and gas projects in residential areas	At receptors or edge of property boundary	45
Alberta, Canada –	15 metres from a dwelling/receptor	
low traffic noise, low density[9]		40
med, traffic noise, low density		45
med. traffic noise, med. density		43
low traffic noise, high density		46
high traffic noise, high density		56
Sacramento County, CA	At residential properties	45
City of Longbeach, CA	At residential property line	45

[5] World Bank Group. 1998. *Pollution prevention and abatement handbook 1998: toward cleaner production.*
*(*http://ifcln1.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_onshore_WB/$FILE/onshore_PPAH.pdf)

[6] California Department of Conservation. January 28, 2003. *California Crude Oil Production Drop Continues-- Natural Gas Production Rises Again.*
(http://www.consrv.ca.gov/index/news/2003%20News%20Releases/NR2002-02_OilandGasReport.htm)

[7] Planning and Community Development Department General and Advanced Planning Section, County of Sacramento, CA. *Noise Element Of The1993 County Of Sacramento General Plan.* 1993. p. 6. (http://www.saccounty.net/general-plan/gp-home.html)

[8] http://www.longbeach.gov/apps/cityclerk/lbmc/title-08/chapter-8-80.htm#TopOfPage

[9] * Dwelling density: low (1-8 dwellings), medium (9-160), high (>160).
Traffic noise: low (more than 500 m from heavily traveled traffic routes), medium (between 30 and 500 m from heavily traveled traffic routes); high (<30 m from heavily traveled traffic routes).

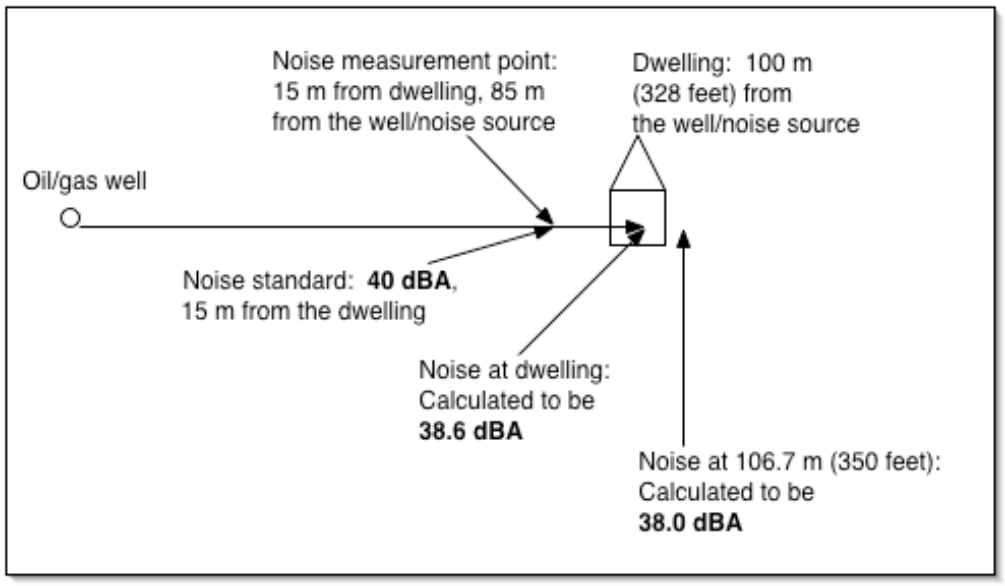
A noise level of 45 dBA at 350 feet from an oil and gas facility <u>is</u> achievable

Experience from different oil and gas producing areas shows that 40 dBA at 350 feet from a facility is achievable.

Alberta, Canada

In personal correspondence with Anita Lewis of the Alberta Energy and Utilities Board (EUB), she stated that all oil and gas facilities constructed after the 1988 Noise Control Directive was put into place have been able to meet the noise standards, including the 40 dBA Leq nighttime standard in low density, low traffic areas (measured 15 meters from residences).[10]

In Alberta, wells cannot be drilled within 100 metres (328 feet) of any surface improvement, which includes dwellings and other buildings.[11] Assuming a well is drilled 100 metres from a dwelling, and the noise standard is 40 dBA at 15 metres from that dwelling (i.e., at 85 m from the noise source), then the actual noise at the dwelling would be less than 45 dBA. Using the calculation for noise attenuation (See Appendix 1), it would be approximately 38.6 dBA at the dwelling. At 350 feet (106.7 metres), the noise would be approximately 38 dBA. Thus, it is definitely possible to achieve a dBA level of 45 dBA at 350 feet from the noise source.



It is interesting to note that when the EUB first enacted its comprehensive Noise Control Directive in 1988, which included the 40 dBA requirement for low density, low traffic areas, there was no resistance from the oil and gas industry. As Ms. Lewis reports, "Industry looks for certainty in the expectations to meet

[10] Anita Lewis. August 3, 2005. Response to an email sent by Lisa Sumi, OGAP,
[11] Alberta Regulation 151/71. *Oil And Gas Conservation Act.* Regulations, Part 2, Section 2.110(1) "Surface Improvements."
http://www.eub.gov.ab.ca/bbs/requirements/actsregs/ogc_reg_151_71_ogcr.pdf

requirements. The 1988 version of the Noise Control Directive provided the means to establish that certainty." (See Appendix 4 for the full email correspondence from Anita Lewis.)

Farmington, New Mexico

Closer to home, there are examples that show that 40 and 45 dBA is achievable at 300-350 feet from the source. The City of Farmington, New Mexico uses "1 dBA over ambient" as a standard for all wells constructed in the city. As seen in the table below, this has resulted in low noise levels from oil and gas facilities within city limits.

In January of 2005, Curt Weitkunat, Associate Planner with the City of Farmington, led some OGAP staff on a tour of wells in and around Farmington, New Mexico. On this tour OGAP conducted sound measurements. The following table summarizes the readings recorded at several sites.

Noise Levels Measured at Gas Wells in Farmington, NM (January 7, 2005)

Well Name	Measured dBA			Estim dBA	Comments
	~100 ft	~200 ft	~300 ft	~350 ft	
Federal A #3	44	41	39	37.7	• Abated compressor; no pumpjack on site
Federal GasCom E#1&2	44	44	42	40.7	• Abated compressor and pumpjack • Traffic noise at 200' and 300'
Possible Dream #1	48.5	47	45	43.7	• Abated compressor; **pumpjack not abated**. • Construction noise present, especially at 200' and 300'
Tiger #9	46	42	41	39.7	• Abated compressor and pumpjack • Air traffic noise at 300'
Tiger #15	54	51.5	48.5	47.2	• Abated compressor and **partially abated pumpjack** • Air traffic noise present

Note that at the sites where the compressors and pump jacks have full sound abatement (Federal A #3, Federal Gas Com E #1&2 and Tiger #9,) the noise levels measured at 300 feet were at or below 42 dBA. This was even true when external noises (e.g., traffic and construction) were present. In the cases where the noise at 300 feet exceeded 42 dBA, the compressors and pump jacks only had partial sound abatement. Even so, one of these sites (Possible Dream #1) still achieved a dBA level of 45 at 300 feet from the noise source.

Outdoor noise levels usually decrease with increasing distance from the source because of geometrical spreading of the noise energy over a bigger surface and absorption of the noise by the atmosphere and by the ground. Based on this generalized assumption, an equation has been formulated to estimate the noise at different distances from a noise source.[12] Using this equation, the noise levels at 350 were calculated. It was estimated that all but one of the wells would be in compliance with a 45 dBA noise standard at 350 feet, which shows that it is possible to achieve this standard even with compressors and pumpjacks on site.

ATCO Compressor Noise Examples[13]
ATCO Noise Management has been able to achieve noise abatement on compressor stations and gas transmission facilities down to 33 dBA at 300 feet. Without acoustical treatment these compressor stations would generate noise levels ranging from 100 - 140 dBA (for the human ear, the threshold of pain is approximately 120 dBA, which is equivalent to the sound of a jet aircraft at takeoff).

1) TransCanada Pipeline expansion across Canada, 1992: Acoustic buildings were added to deaden the noise at two new compressor stations in noise sensitive areas. According to ATCO, "Near several cottage communities, we had to build stations with noise levels as low as technically feasible. This meant achieving levels of 33 dbA for each station component, such as the gas turbines and compressors."

2) Iroquois Gas Transmission's Croghan, New York, station: Achieved design goal of 40 dB at 300 feet by treating each significant noise source, i.e., gas turbines and compressors, exhaust and intake, oil cooler, cooling and ventilation fans; and also built the compressor station to look like a barn to fit in with rural countryside.

3) TransCanada Pipeline, 1993 (Dryden, Smooth Rock Falls and Barrie, Ontario): Three stations met noise levels of 33 dBA at 300 feet. Noise sources consisted of a gas generator and power turbine (was producing noise at 90 dBA at 1 meter) and two centrifugal compressors (was 105 dBA at 1 meter), as well as gas generator air inlets, turbine exhausts and lube oil coolers.

4) TransCanada Pipeline expanded gas transmission network by 13 units in 1997: They reduced noise from 105 dBA to 36 dBA at 300 feet at these units, and achieved 39-44 dBA at the remaining 11 stations. "One station runs so quietly that a nearby resident asked when it'd be operational."

[12] Based on this generalized understanding of noise attenuation, an equation has been developed to estimate the noise at different distances from a noise source. This equation appears in the COGCC proposed rule, section c.(1). It can also be found in Appendix 1.
[13] ATCO Noise web site: http://www.atconoise.com/mediaroom/mediaroom_tech_history.htm

RECOMMENDATION 2. Add an ambient noise adjustment factor to Section c.(5).

As written, Section c.(5) of the proposed rule does not explain what will occur after the existing ambient noise from sources other than the oil or gas operation are considered. No proposed language for this was worked out during the Noise Stakeholder Group meetings.

> **Proposed new language for the noise rule (changes are underlined):**
>
> **802. NOISE ABATEMENT**
> c.(5) In all sound level measurements, the existing ambient noise level from all other sources in the encompassing environment at the time and place of such sound level measurement shall be considered to determine the contribution to the sound level by the oil and gas operation(s). <u>If the measured ambient noise exceeds the noise standard in the residential/rural/agriculatural zone the oil or gas operations shall be allowed to emit noise at a level that is 1 dBA greater than the measured ambient noise (to a maximum of 5 dBA over the noise standard).</u>

This proposed language is based on the fact that the City of Farmington, New Mexico uses the 1 dBA over ambient as a standard for all wells constructed in the city. There are more than 200 wells located within the Farmington city limits, and as seen in Section 2.2.2. Thus, we know that this standard is achievable. Appendix 5 has copies of two recent gas well applications in Farmington, NM. The applications were approved with the condition that: "The ambient sound levels from the subject property shall not be increased more than 1 dB(A) when measured at 300 feet."

Also, people generally cannot detect differences of less than 1 dBA if the background noise is of the same character (e.g., new traffic noise added to existing traffic noise). If the intruding noise is of a different character than the background noise (e.g., the whine of a new compressor turbine superimposed onto rural background noise) then the intruding noise could be easily discernible even if it adds less than 1 dBA to the background noise level.[14] Despite this, we believe that an adjustment factor of 1 dBA over ambient will provide the oil and gas industry with the ability to exceed the residential/rural/agricultural noise standards while not drastically changing the ambient noise environment in any particular area.

A maximum allowance of 5 dBA over our proposed COGCC residential/rural/agricultural noise standard was added because 5 dBA above 45 dBA is 50 dBA, which is the maximum permissible residential noise level under Colorado State law.[15]

We did not apply a similar ambient adjustment to the commercial, light industrial or industrial zones because the proposed dBA levels for these zones are already at Colorado State nuisance levels. Thus, any increase would result in non-compliance with a state law.

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[14] Wallula Power Project DEIS. February, 2002. Section 3.9: Noise. p. 3.9-1.
[15] Colorado Revised Statutes. Title 5. Health – Environmental Control. Article 12. Noise Abatement. Section 25-12-103. Maximum permissible noise levels.

RECOMMENDATION 3. Revise the low frequency noise trigger and add a low frequency noise standard to the proposed noise rule.

As written, Section d. of the proposed rule does not provide a low frequency noise standard to meet, only a trigger for a low frequency noise study. Without an actual low frequency noise standard, there is no way to judge whether or not an oil and gas operator is in compliance with the noise rule.

Proposed new language for the noise rule (changes are underlined):

802. NOISE ABATEMENT

d. In situations where the complaint or commission onsite inspection indicates that low frequency noise is a component of the problem, the commission shall obtain a sound level measurement twenty-five (25) feet from the exterior wall of the residence or occupied structure nearest to the noise source, using a noise meter calibrated to the dB(C) scale. If this reading exceeds <u>60 dB(C)</u> the commission shall require the operator to obtain a low frequency noise impact analysis by a qualified sound expert, including identification of any reasonable control measures that shall be employed to mitigate such low frequency noise impact <u>to achieve a level of 60 dB(C) or to remove offending low frequency tones to the satisfaction of the complainant.</u> Such study shall be provided to the Commission for consideration and possible action.

The proposed new language is based on information obtained while attending an environmental noise conference hosted by the Alberta EUB.[16] Several of the presentations focused on low frequency noise from industrial sources, including oil and gas facilities.

Two papers presented at the conference specifically addressed the need to develop low frequency noise criteria for noise emissions from industrial sources. These papers can be obtained from the Alberta Energy and Utilities Board.[17]

One presenter, Jim Farquharson, provided data from noise surveys showing that in 6 out of 8 cases there were complaints of low frequency noise when dBC levels were above 54 dB.[18] In two instances, however, dBC > 62 but there were no complaints. This highlights the fact that not all people respond negatively to low frequency noise. Farquharson also noted that when the difference between dBC and dBA exceeds 20, the potential for a complaint increases.

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[16] In May of 2005, Lisa Sumi, Research Director with the Oil and Gas Accountability Project attended the 2005 Spring Conference on Environmental and Occupational Noise *For whom the decibel tolls: reducing the impact of noise.* The conference was hosted by the Alberta EUB. Prior to the conference, Lisa also attended a workshop on Basic Acoustics I and II, which was presented by Acoustical Consultants Inc. of Edmonton, Alberta.

[17] Contact Anita Lewis, AEUB. (403) 297-3793. Anita.Lewis@gov.ab.ca

[18] Farquharson, J. 2005. "C-A weighting sound monitoring survey case studies." Paper presented at the 2005 Spring Conference on Environmental and Occupational Noise *For whom the decibel tolls: reducing the impact of noise.* Banff, Alberta. May23-26, 2005.

A second presenter, George Hessler, recommended that a dBC level of 60 dB not be exceeded in quiet, rural areas (i.e., below 40 dBA), if the industrial operation runs 24-hours-a-day, 7-days-a-week. These conditions will definitely apply in parts of rural Colorado that are undergoing oil and gas development. For residential areas that have ambient noise levels above 40 dBA, Hessler recommended that a dBC value of 65 should not be exceeded.[19] In his paper, Hessler explains that these proposed criteria were derived from investigating a valid but relatively small sampling of problem sites, and cautions that the criteria may need to be lower to account for the variable nature of human response to low frequency sound. Based on Hessler's recommendations, as well as Farqurharson's data, we believe that a low frequency noise standard of 60 dBC should be protective of the majority of low frequency noise sufferers.

Hessler also mentioned that if the dBC minus dBA level exceeds 20 dB, that the low frequency content of the noise is excessive. This is another method of determining if there is a low frequency noise problem. COGCC staff and industry may want to employ this method as a means of double-checking the simple dBC measurement.

[19] Hessler, G. Jr. 2004. "Proposed criteria in residential communities for low-frequency noise emissions from industrial sources," *Noise Control Engineering.* July/August, 2004. 52(4):179-185.

RECOMMENDATION 4. Require all non-electric engines located close to occupied buildings to have quiet design mufflers or equivalent.

Proposed new language for the noise rule (changes are underlined):

802. NOISE ABATEMENT

f. All facilities within four hundred (400) feet of occupied buildings with engines or motors which are not electrically operated shall be equipped with quiet design mufflers or equivalent. All mufflers shall be properly installed and maintained in proper working order.

The proposed new language removes the reference to facilities located in “high density” areas. We believe that if there is one person or 50 located within 400 feet of the oil and gas operation, that noise abatement should be applied to non-electrical engines. These mufflers are inexpensive (approximately $1000 for a good quality muffler/silencer), but provide both oil and gas workers and nearby citizens with a quieter, more pleasant environment.

3.0 COSTS AND BENEFITS OF CHANGING THE PROPOSED NOISE RULE.

3.1 The real and incremental costs of noise abatement

In May, 2005, OGAP Research Director, Lisa Sumi, attended a conference on Environmental and Occupational Noise in Alberta, Canada. There were several presentations on noise related to oil and gas, and Doug Walker of Noise Solutions, Inc. provided information on noise mitigation. Lisa followed up with Doug Walker by email to obtain cost information for the different noise mitigation options.[20] (See Appendix 6 for details.)

Factored over the life of a well, or compared to the costs of drilling and operating wells or constructing compressor stations, it appears that the costs of noise abatement are minor.

According to a study conducted for the Colorado Department of Natural Resources, in 2000 it cost small companies an average of $300,000 to drill and complete a well in Colorado.[21] Medium and large companies spent approximately $550,000 on their wells. Meanwhile, according to Doug Walker of Noise Solutions, Inc., the noise mitigation cost for a well site compressor is approximately $10,000, which is not going to make-or-break the economics of a $300,000 – 500,000 well. Incrementally, this cost is only 3-5% above the cost of drilling and completing a well.

Moreover, with oil and gas prices at all-time highs, the profits being made from many wells in a matter of days would easily cover the cost of using sound abatement equipment. In the first half of 2005, the average wellhead price of natural gas has remained steady at approximately $6.00 per thousand cubic feet of gas (MCF).[22] At these prices, a well that produces 100 MCF per day will be able to cover the cost of a $15,000 noise abatement project in 25 days. A well that produces 10,000 MCF per day will be able to pay for a $15,000 noise abatement package four times over based on the sale of one day's worth of gas.

Larger compressor stations typically utilize some sort of enclosure to protect the compressor equipment and workers from the elements. Doug Walker estimates that such a building without acoustic controls cost $50,000-$60,000. The cost of designing and building-in acoustic controls may add up to 20% ($10,000 - $12,000) to the cost of the enclosure. Meanwhile, the cost to construct the compressor station itself is in the million-dollar range.[23] In other words, the incremental cost for noise mitigation is

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[20] Email correspondence between Lisa Sumi, OGAP and Doug Walker, Noise Solutions, Inc. August 2, 2005. Appendix 6 includes the information on cost estimates provided by Doug Walker.

[21] These numbers are based on information included in the following report: Hazen and Sawyer. 2001. *Economic Comparison of the Rules and Regulations of the Colorado Oil and Gas Conservation Commission (COGCC).* Final Report January 2001. Prepared for the Colorado Department of Natural Resources.

[22] http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm

[23] Email correspondence between Lisa Sumi, OGAP and Doug Walker, Noise Solutions, Inc. August 2, 2005. Appendix 6 includes the information on cost estimates provided by Doug Walker.

approximately 1% (i.e., $10,000 to $12,000 to provide acoustic controls on a million dollar compressor facility).

3.2 The cost of being a "good neighbor"

The oil and gas industry often talks about how oil and gas companies want to be "good neighbors."[24] One obvious component of being a good neighbor is to keep noise levels from oil and gas operations down. Unwanted noise can deeply affect the well-being of people, and can create animosity where before there was none. In a paper given during the noise conference in Alberta, a lawyer talked about how noise was the issue that first riled landowners, and when their issues were not resolved it greatly increased their scrutiny of nearby oil and gas projects, slowing down permitting processes and creating a greater rift between the landowners and operators. While operators may see noise abatement as an up-front expense, they may want to consider that it is merely part of the cost of maintaining good working relationships with their neighbors.

3.3 The economic benefits of noise abatement

In a personal correspondence with Anita Lewis of the Alberta EUB, Lisa Sumi questioned Ms. Lewis as to whether there was a solid noise abatement industry in Alberta at the time the 1988 Noise Directive was enacted, or whether the noise abatement industry grew out of the EUB noise requirements. According to Ms. Lewis:

> *There was a small but solid noise abatement industry in place in 1988. Since then, it has grown to several times that size to include not only measurement and assessment but to companies who engineer specific solutions, manufacture them and install them. Alberta acoustical engineering capabilities are being used internationally and selected by NASA to undertake significant noise abatement of the shuttle crawlers.*[25]

There were several presentations at the Alberta environmental noise conference that discussed the North American and worldwide trend toward more stringent noise regulations.[26] Thus, if Colorado can establish a healthy noise abatement industry related

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[24] In a letter to the Bureau of Land Management, the Colorado Oil and Gas Association and two other industry groups commented that, "Technological advances in such areas as directional drilling, project development scheduling, and reclamation practices have allowed the industry to be an environmental steward and a good neighbor." Source: Letter from Greg Schnacke (Colorado Oil and Gas Association), Claire Mosely (Public Lands Advocacy) and Andrew Bremner (Independent Petroleum Association of Mountain States) to Greg Goodenow, Bureau of Land Management. April 11, 2005. RE: Roan Plateau Draft Resource Management Plan Amendment/Draft Environmental Impact Statement. (Letter can be found on the web at: http://www.policycommunications.com/ roan/RoanPlateauComments.pdf)

[25] See Appendix 4.

[26] Rassin, B. 2005. "Noise Control Trends World Wide." AND Penton, R.L.S., Vandelden, P., and Chadder, D. 2005. "The Current State Of Noise Requirements For Federal Environmental Assessment Purposes – Redux. 2005." Papers presented at the 2005 Spring Conference on Environmental and Occupational Noise *For whom the decibel tolls: reducing the impact of noise.* Banff, Alberta. May23-26, 2005.

to oil and gas facilities, it seems likely that there will be a great deal of opportunity for growth and prosperity in this sector.

Colorado has the opportunity to enact one of the more effective noise rules related to oil and gas operations in the country. By enacting noise regulations at a time when companies can easily afford noise mitigation technologies Colorado companies will be in a better position to compete with companies in other jurisdictions that may have to bear the noise abatement costs at a time when their profits are less spectacular.

Appendix 1

BACKGROUND INFORMATION ON NOISE

There are some key concepts and facts related to noise that are important to understand prior to making a decision regarding acceptable noise rules for oil and gas facilities.

What is the difference between sound and noise?[27]

Sound is defined as any pressure variation heard by the human ear. Noise is often defined as unwanted sound. The pressure variations heard by healthy human ears translates into a range of frequencies from 20 Hz to 20,000 Hz.

How do humans perceive sound?

In terms of sound pressure, the human ear's range starts at the threshold of hearing (0 dB) and ends at the threshold of pain (around 140 dB).

As a rule of thumb, a doubling in the loudness of the sound occurs with every increase of 10 dB in sound pressure. In other words, for most individuals a 60 dBA noise would sound twice as loud as a 50 dBA noise.

The human ear is less sensitive to sound pressure variations in the low frequencies compared to the higher frequencies. A low frequency sound at 50 Hz must be 15 dB higher than a tone of 1000 Hz at a level of 70 dB to be perceived as the same loudness by the listener.

What is the calculation for noise at various distances from a noise source?

Under free field conditions, point sources produce noise that spreads uniformly as a sphere, similar to water ripples on a pond. In the free field, sound pressure increases as one moves closer to the noise source and decreases as one moves further away. The formula used to calculate the SPL at a known distance away from a noise source in the free field is:[28]

$$L_p(R2) = L_p(R1) - 20 \log_{10}\left(\frac{R2}{R1}\right) \quad [dB]$$

Where:

L_p (R1)	= Sound Pressure Level at the initial location
L_p (R2)	= Sound Pressure Level at the new location
R1	= distance from the noise source to the initial location
R2	= distance from the noise source to the new location

All noise is not equally annoying

Not all noise has the same effect on humans, nor do all humans react in the same way to noise stimuli. Certain noise characteristics can greatly increase the

[27] The information in Sections 2.1 and 2.1.1. come from the following source: ATCO Noise Management. October, 1999. *Environmental Noise Control Handbook.* http://www.atconoise.com/mediaroom/NOISE_HANDBOOK.pdf

[28] ATCO Noise Management. October, 1999. *Environmental Noise Control Handbook.* p. 26.

annoyance factor and the potential health impacts associated with noise. In addition to decibel level or loudness, these factors include: 1) difference between the new noise and the prior ambient noise environment; 2) the presence of specific tones; 3) low frequency noise; 4) fluctuating or intermittent sounds; and 5) impulsive sounds.

AMBIENT NOISE

As mentioned in Section 1.0, one of the challenges that the COGCC has to contend with is the fact that ambient noise levels vary both across the state and within the established zoning categories (e.g., residential, commercial, light industrial, industrial).

Howard McGregor of Engineering Dynamics, Inc. out of Englewood, Colorado, has stated that ambient noise levels in valleys and hillsides in mountainous regions are frequently less than 35 dB(A) during the nighttime, and occasionally lower.[29] Similarly, the Alberta Energy and Utilities Board states that the rural ambient sound level in Alberta is approximately 35 dBA Leq at night.[30] Residential neighbourhoods in towns or cities are likely to have ambient noise levels that are higher than 35 dBA.

A number of studies suggest that the annoyance effect of a particular noise depends on how much that noise exceeds the level of ambient noise, and on the character of the new noise.[31]

When new noise sources are created, the likelihood of opposition to the noise will increase the more the noise exceeds ambient noise conditions. Conversely, if the noise standards are close to ambient conditions, it is unlikely that there will be large numbers of noise-related complaints.

If the background noise is of the same character (e.g., new traffic noise added to existing traffic noise), then people generally cannot detect differences less than 1 dBA. If the intruding noise is of a different character than the background noise (e.g., the whine of a new turbine superimposed onto rural background noise) then the intruding noise could be easily discernible even if it adds less than 1 dBA to the background noise level.[32]

For ambient noise levels of less than 60 dB, the Federal Interagency Committee on Noise (FICON) considers an increase of 5 dB or more to be a significant change.[33] Consequently, a noise level of 35 dBA would be considered a "significant

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[29] McGregor, H.N. Propagation of Noise from Gas Compression Facilities Located in Mountainous Terrain. (Handout at the first COGCC Noise Stakeholder Meeting.)

[30] Alberta Energy and Utilities Board (EUB). November, 1999. *Noise Control Directive User Guide*. (Guide 38). p. 15.

[31] Bradley, J.S. 1993. Disturbance Caused by Residential Air Conditioner Noise. Journal of the Acoustical Society of America 93: 1978-1986. *Cited in* Berglund, B., Lindvall, T. and Schwela, D. 1999. *Guidelines for Community Noise*. World Health Organization. Chapter 2, p. 28. http://www.who.int/docstore/peh/noise/Commnoise2.htm

[32] Wallula Power Project DEIS. February, 2002. Section 3.9: Noise. p. 3.9-1.

[33] Sacramento County, CA. 2005. *The Residences of Murieta Hills & The Retreat –DEIR. Chapter 9. Noise. http://*www.dera.saccounty.net/01-0069%20Residences/09%20Noise.pdf

change" by some. As explained earlier, an increase of 10 dB is perceived by most to be twice as loud as the original sound level.

During the COGCC noise stakeholder meetings, OGAP and the San Juan Citizens Alliance put forward a proposal to limit noise levels to one decibel over the ambient level. We based this suggestion on the fact that even though a 1 dBA increase over the ambient level may be discernible, that this level of increase in noise would be acceptable to most people. This proposal was rejected, primarily because many stakeholders thought the ambient noise measurement would be too complex to work into the proposed noise rule.

Yet there are oil and gas producing jurisdictions that relate their noise standard in some fashion to the ambient noise level.

Farmington, New Mexico: The City of Farmington, New Mexico uses the 1 dBA over ambient as a standard for all wells constructed in the city. There are more than 200 wells located within the Farmington city limits.

Appendix IV has copies of two recent gas well applications in Farmington, NM. The applications were approved with the condition that: *The ambient sound levels from the subject property shall not be increased more than 1 dB(A) when measured at 300 feet.*

Note that the 1 dBA over ambient applies not only to "single family residential districts," but also to "light industrial districts."

Alberta, Canada: Alberta EUB allows an ambient adjustment factor for situations where the basic nighttime sound levels are thought not to be representative of the actual sound environment.[34] The EUB uses an adjustment factor for these situations. Below are some examples of how different ambient levels affect the adjusted allowable noise level.

Original noise standard (dBA)	Ambient level (dBA)	New acceptable noise level (dBA)
40	30	35
40	32	37
40	35	40
40	42	47
40	50	50

In Alberta, if the ambient noise is considerably different that the noise standard (e.g., 10 dB), the adjusted noise standard better reflects the noise environment, thus providing residents in quiet areas with more protection, and also allowing industry to emit more noise when ambient levels are higher.

Although the FICON recommendations were specifically developed to assess aircraft noise impacts, it has been assumed in some jurisdictions that they are applicable to all sources of noise that are described in terms of cumulative noise exposure metrics such as the Ldn.

[34] Alberta Energy and Utilities Board (EUB). February, 2005. *Draft Noise Control Directive User Guide*. (Guide 38). p. 61.

TONAL NOISE

> *Noise with distinct tones, for example, noise from fans, compressors, or saws, is generally far more annoying than other types of noise.*[35]
>
> ~ *Environmental Noise Handbook*, Breul and Kjaer

> *Most energy industry facilities typically exhibit either a tonal or impulse/impact component. Examples of tonal components are transformer hum, sirens, and piping noise.*[36]
>
> ~ *Noise Control Directive User Guide*, Alberta Energy and Utilities Board

Most environmental noise is composed of a complex mix of many different frequencies. They may or may not have discrete frequency components superimposed on broadband noise (i.e. sound with a broad range of frequencies).[37] ***Tones*** are noises with a narrow sound frequency composition. Annoying tones can be created in numerous ways: machinery with rotating parts such as motors, gearboxes, fans and pumps often create distinct tones. Unbalance or repeated impacts cause vibration that, transmitted through surfaces into the air, can be heard as tones. Pulsating flows of liquids or gases can also create tones, caused by combustion processes or flow restrictions.

Tones can be identified subjectively by listening. Noise regulations, however, usually require an objective measurement of tonal content.[38] In such cases, frequency analysis, where a noise signal is electronically separated into various frequency bands may be employed. The tonal audibility or annoyance factor is then calculated by comparing the tone level to the level of the surrounding spectral components.[39]

In some noise regulations, when tonal components are present, a penalty is imposed on the noise source. For example, if the measured decibel level is 58 dBA at 350 feet, but tonal components were present, a penalty of 5 dBA could be applied. This would bring the "calculated" decibel level at 350 feet to 63 dBA. If the noise standard for this situation was 60, the operator would be out of compliance until they either reduced the overall decibel levels, or removed the tonal components from the noise.

Measuring tonal noise using 1/3-octave band frequency analysis

Germany (DIN 45680 method)[40]

In Germany, there is an assumption that the great majority of low

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[35] Breul and Kjaer. 2000. *Environmental Noise Handbook.* p. 25.
[36] Alberta Energy and Utilities Board (EUB). November, 1999. *Noise Control Directive User Guide*. (Guide 38). p. 67.
[37] Berglund, B., Lindvall, T. and Schwela, D. 1999. *Guidelines for Community Noise*. World Health Organization. p. xii.
[38] Breul and Kjaer. 2000, p. 25.
[39] Note: the duration of the tone should also be documented according to Breul and Kjaer, p. 15.
[40] Leventhall, G. 2003. *A Review of Published Research on Low Frequency Noise and Its Effects.* p. 69.

frequency noise problems from industrial sources are tonal. (See low frequency noise, below). For tonal frequencies, the allowable noise limit is less than for non-tonal noises.

If the level in a particular third-octave band is 5 dB or more above the level in the two neighboring bands, the noise is described as tonal. This is similar to a standard for tonality set by the ISO (1987).[41]

Alberta Energy and Utilities Board (EUB)[42]
In Alberta, if no tonal noise is present, oil and gas operators are allowed to emit noise at 5 dBA above the basic allowable noise level.

The test for the presence of tonal components consists of two parts.

1) The sound pressure level of any one of the slow-response, A-weighted, 1/3-octave bands between 20 and 16 000 Hz is 10 dBA or more than the sound pressure level of at least one of the adjacent bands within two 1/3-octave bandwidths. In addition, there must be a minimum of a 5 dBA drop from the band containing the tone within two bandwidths on the opposite side.
2) The tonal component must be a pronounced peak clearly obvious within the spectrum.

Figure 1 (below) shows some examples of tonal components:

250 Hz: There is a qualifying tonal here because to the left of 250 bar there is a drop of 11 dBA within 2 bandwidths. On the opposite side, there is a drop of 6 dBA. Also, the tone at 250 Hz is pronounced within the spectrum.

2000 Hz: This is also tonal, as there are drops of more than 10 dBA within two bandwidths on the left side, and more than 5 dBA within two bandwidths to the right.

630 Hz: The sound measurement at this frequency meets part of the test. It is pronounced within the spectrum, and there is a 5 dBA difference within 2 bandwidths to the right of 630 Hz. It does not, however, meet the full test because there is no corresponding drop of at least 10 dBA within one or two bandwidths on the other side.

[41] International Standard ISO 199602:1987. Cited by the Ireland Environmental Protection Agency. (http://www.epa.ie/Noise/)
[42] Alberta Energy and Utilities Board (EUB). November, 1999. *Noise Control Directive User Guide*. (Guide 38). p. 28.

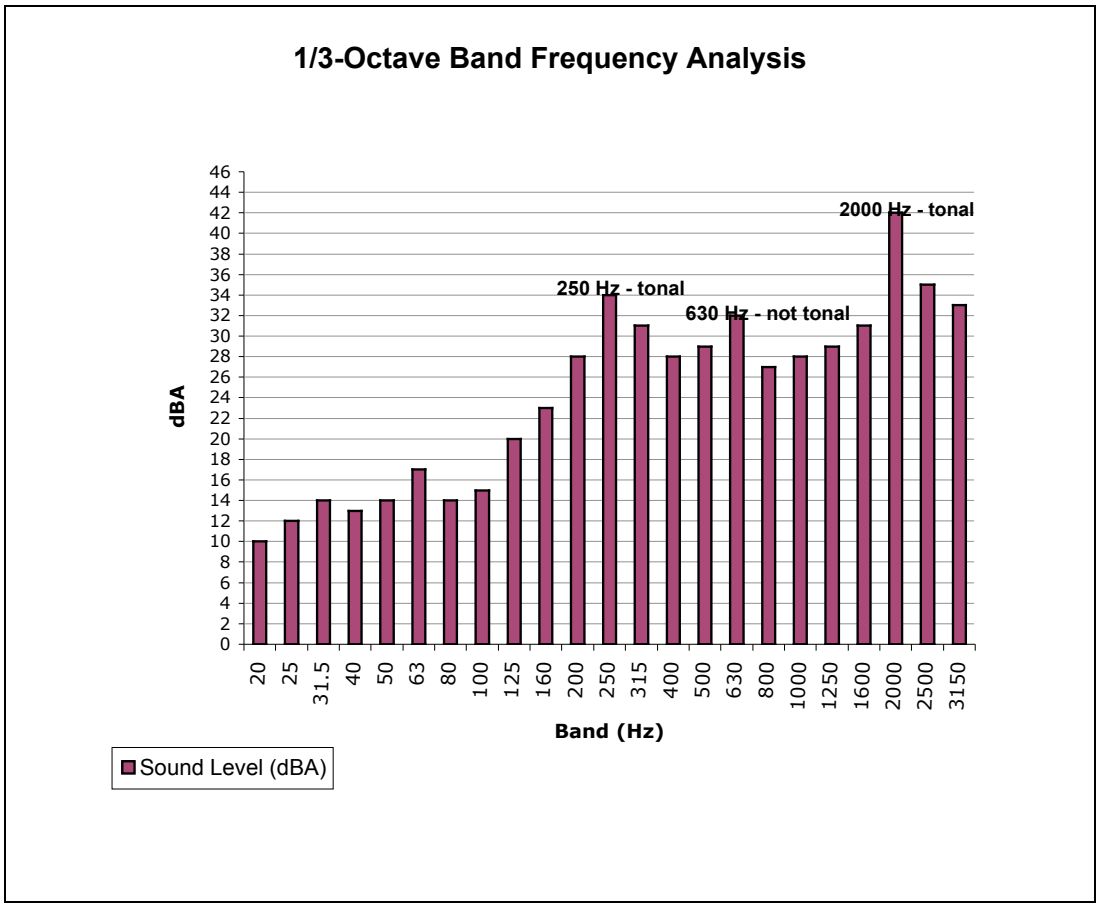

Figure 1. 1/3-Octave Band Frequency Analysis

Oregon *Noise Control Regulations*[43]
Oregon requires the use of octave bands to determine audible discrete tones from industrial noise "when the Director has reasonable cause to believe that the requirements of [the Oregon Noise Control Regulations] do not adequately protect the health, safety or welfare of the public." The *Oregon Noise Control Regulations* outline a procedure for determining whether or not the noise contains tonal components.

Penalties for tonal noise
In some jurisdictions, when noise has an obvious tonal content, a "penalty" or correction may be used to account for the additional annoyance.[44] The penalty for tones varies between 0 dB (no penalty) and 6 dB.[45] This penalty is added to the measured dB level before the measured dB level is compared to the

[43] Oregon Administrative Rules, Chapter 340, Division 35, *Noise Control Regulations*. 340-35-035 (1)(f).
[44] ISO , 1987. *Acoustics – Description and measurement of environmental noise – Part 3: Application to noise limits.* International Standard ISO 1996-3:1987(E), International Organization for Standardization, Geneva, Switzerland. *Cited in* Berglund, B., Lindvall, T. and Schwela, D. 1999.
[45] Breul and Kjaer. 2000, p. 31.

acceptable dB noise levels.

For example, if the noise from a compressor is measured as 40 dBA, but it is determined that the noise has tonal components, a penalty of 6 dBA would result in a level of 46 dBA. If the noise standard is 45 dBA, the noise from the compressor would be out of compliance.

LOW FREQUENCY NOISE

> *A large proportion of low-frequency components in noise may increase considerably the adverse effects on health.*
>
> *. . .low frequency noise. . . can disturb rest and sleep even at low sound levels.*
>
> *The evidence on low frequency noise is sufficiently strong to warrant immediate concern.*
>
> ~ *Guidelines for Community Noise,* World Health Organization

Low frequency noise does not have a consistent definition, but it commonly defined as noise that has a frequency between 20 and 100 - 150 Hz. Noise at levels below 20 Hz is referred to as infrasound.

Depending on the actual conditions, many types of noise can be regarded as low frequency noise:[46]

- Low frequency noise and infrasound are produced by machinery, both rotational and reciprocating, and all forms of transport and turbulence. Typical sources include pumps, compressors, diesel engines, aircraft and fans.
- Combustion turbines are capable of producing high levels of low frequency noise. This noise is generated by the exhaust gas.[47]
- The firing rate of many diesel engines is usually below 100 Hz, so road traffic noise can be regarded as low frequency. Similar considerations can be made for engines or compressors in industries or co-production plants.
- Burners can emit broadband low frequency flame roar.
- Structure borne noise, originating in vibration, is also of low frequency, as is neighbor noise heard through a wall, since the wall blocks higher frequencies more than lower ones.
- Low frequency noise can be noise or vibration from traffic or from industries, totally or partly transmitted through the ground as vibration and reradiated from the floor or the walls in the dwelling.[48]

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[46] *Laboratory Evaluation of Annoyance of Low Frequency Noise*., by Torben Poulsen,and Frank Rysgaard, 2002. Prepared for the Danish Environmental Protection Agency.
[47] Defined as frequencies less than 64 Hz. Walulla Power Project DEIS. P. 3.9-3. Feb. 2002.
[48] Poulsen, Torben and Rysgaard, Frank. 2002. *Laboratory Evaluation of Annoyance of Low Frequency Noise*. Prepared for the Danish Environmental Protection Agency. Working Report No. 1. p. 14.

Low frequency noise creates a large potential for community annoyance. It is most often experienced inside of homes and buildings where resonance amplifies the sound. (See Attachment 2) It is a general observation that indoor noise is perceived as more 'low-frequency-like' than the same noise heard out of doors.[49]

Also, low frequency noise can be a factor at much greater distances than audible noise sources. A case study in Northern Carolina near a wind turbine documented low frequency noise problems at residences located more than 1/2 mile from the turbine.[50]

Health effects of low frequency noise

It is well established that the annoyance due to a given noise source is perceived very differently from person to person. For many humans, their ears are not very sensitive to low levels of low frequency sound. At low frequencies, however, noise may not be perceived as sound but rather is "felt" as a vibration or pressure sensation.[51]

For those who are sensitive to low frequency sound the effects can be dramatic. Complainants often describe the noise as:[52]

- Humming
- Rumbling
- Constant and unpleasant
- Pressure in ears
- Affects whole body
- Sounds like large, idling engine
- Coming from far away

Researchers who conducted field measurements and laboratory studies of people who complained of low frequency noise in their homes concluded the following:[53]

- The problems arose in quiet rural or suburban environments
- The noise was often close to inaudibility and heard by a minority of people
- The noise was typically audible indoors and not outdoors
- The noise was more audible at night than day
- The noise had a throbbing and rumbly characteristic
- The complainants had normal hearing

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[49] *Laboratory Evaluation of Annoyance of Low Frequency Noise*., by Torben Poulsen,and Frank Rysgaard, 2002. Prepared for the Danish Environmental Protection Agency.

[50] Solar Energy Research Institute(SERI). 1985. Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact and Control. Colorado: SERI, U.S. Department of Energy.

[51] Breul and Kjaer. 2000, p. 15; and Casella Stanger. 2001. *Low Frequency Noise.* (Technical research support for U.K. Department for Environment, Food and Rural Affairs Noise Programme). p. 4.

[52] Moller and Lydolf, 2002. Based on a Denmark survey of people complaining of low frequency noise. *Cited in* Leventhall, G. 2003, p. 48,

[53] Vasudevan, R. N., and Gordon, C. G. 1977. "Experimental study of annoyance due to low frequency environmental noise," *Applied Acoustics.* Vol. 10, pp. 57-69. *Cited in* Leventhall, G. 2003, p. 36.

In an epidemiological survey of sufferers from low frequency noise, the following health effects were documented:[54]

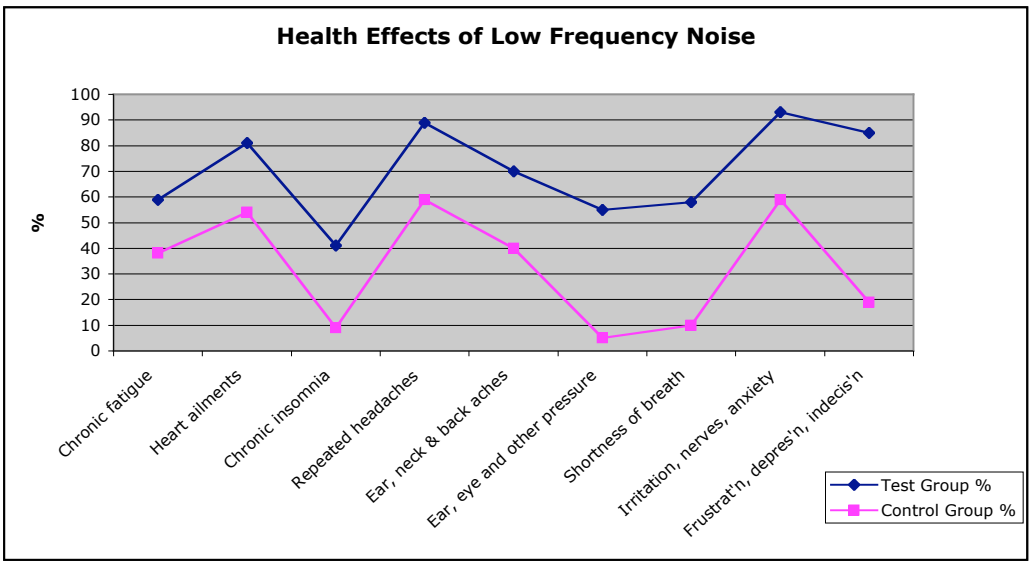

Figure 2. Health effects of low frequency noise.

The above health effects were felt by people experiencing low frequency noise in their homes. The New Mexico Game and Fish states that even for human beings in a recreational setting, low frequency noise has been shown to cause stress reactions including raised blood pressure and increased muscle tension.[55]

Measuring low frequency noise

When prominent low-frequency noise components are present, noise measurements based on A-weighting are inappropriate.[56] A-weighting has the effect of reducing measured levels of low and very high frequencies (see Figure 3), but has less filtering effect on most mid-range sound frequencies where speech and communication are important.[57]

[54] Mirowska, M., and Mroz, E. 2000. "Effect of low frequency noise at low levels on human health in light of questionnaire investigation," *Proc Inter-Noise 2000, 5, 2809 - 2812*. *Cited in* Leventhall. 2003. p. 49.
[55] Federal Energy Regulatory Commission. http://216.239.57.104/search?q=cache:05wK5TjE1tMJ:www.ferc.gov/whats-new/comm-meet/072804/C-2.pdf+compressor+station+low+frequency+ferc&hl=en
[56] Berglund, B., Lindvall, T. and Schwela, D. 1999. p. xiii.
[57] Leventhall, G. 2003. p. 10.

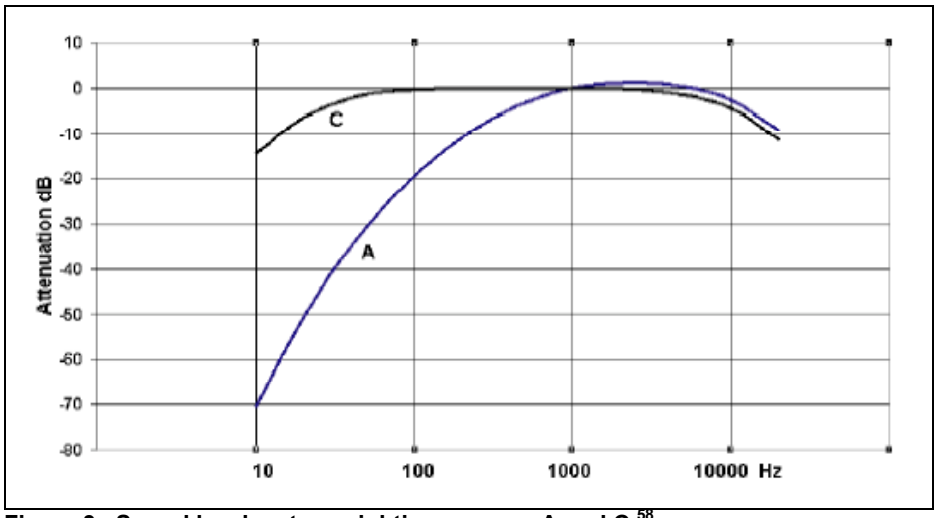

Figure 3. Sound level meter weighting curves - A and C.[58]

Berglund et al (1996) have suggested that, "Since A-weighting under-estimates he sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting." The Danish government does not recommend using the C-weighted noise level to assess low frequency noise, however, because "there is a poor relationship between the C-weighting function and the shape of the equal-loudness contours at low frequencies and low levels.[59]

In assessing low frequency noise the following steps have been used in some jurisdictions:

Step 1: Is (dBC – dBA) > x ?

The difference between dBC and dBA provides crude information about the presence of low frequency components in noise. Research suggests that when the difference (x) is great enough, that further investigation or action related to low frequency noise is warranted.

- In Germany, x > 20 dB is used as an initial indication of the presence of low frequency noise, and the need to conduct further investigations.[60]
- If x > 10 dB it is recommended by the World Health Organization that a frequency analysis of the noise be performed.[61]
- Kjellberg and co-workers (1997) have suggested that when x > 15 dB, an addition of 6 dB to the measured A-weighted level is a simple procedure for addressing the annoyance.[62]

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[58] Leventhall, G. 2003. p. 11.

[59] Danish Environmental Protection Agency. 2002. *Danish Guidelines on Environmental Low Frequency Noise, Infrasound and Vibration.* (http://www.mst.dk/transportuk/02030000.htm#vibration)

[60] Leventhall, G. 2003. p. 69.

[61] Berglund, B., Lindvall, T. and Schwela, D. 1999. *Guidelines for Community Noise*. World Health Organization. p. xiii.

[62] Kjellberg, A., Tesarz, M., Holberg, K., and Landström, U. (1997). "Evaluation of frequency-weighted sound level measurements for prediction of low-frequency noise annoyance."

Step 2: Conduct frequency analysis of low frequency noise and compare to criteria.

There are numerous methods for determining the significance of low frequency noise. Over the past 25 years, many European countries (Sweden, the Netherlands, Germany, Denmark) have developed national criteria for environmental low frequency noise. According to Leventhall (2003), the move to develop criteria was driven by specific problems, "particularly gas turbine installations, which radiate high levels of low frequency noise from their discharge."[63]

In Sweden and Germany, low frequency noise may be considered a nuisance if its level exceeds a criterion in any third-octave band.

Table 1. Hearing Thresholds and Allowable dB Levels for Low Frequency Noise

Frequency 1/3 Octave Band (Hz)	ISO 226 [64] Hearing Threshold (dB)	Sweden allowable dB levels	Germany Hearing Threshold (dB)	Germany daytime allowable dB levels (tonal noises)	Germany nighttime allowable dB levels (tonal noises)
8	--		103	108	103
10	--		95	100	95
12.5	--		87	92	87
16	--		79	84	79
20	74.3		71	76	71
25	65		63	68	63
31.5	56.3	56	55.5	60.5	55.5
40	48.4	49	48	53	48
50	41.7	43	40.5	45.5	40.5
63	35.5	41.5	33.5	38.5	33.5
80	29.8	40	28	38	33
100	25.1	38	23.5	38.5	33.5
125	20.7	36			
160	16.8	34			
200	13.8	32			

Denmark has take a slightly different approach than Germany and Sweden, by outlining criteria for infrasound, low frequency noise and audible noise.

- **Infrasound (L_{pG}):** The Danish EPA assumes that infrasound only slightly above the hearing threshold may be annoying. The average hearing threshold for infrasound corresponds to tones each having a G-weighted level of about L_{pG} = 96 dB. An environmentally acceptable infrasound level must be below the hearing threshold. The Danish EPA assumes that an individual's hearing threshold might be 10 dB lower than the average threshold, so the agency's recommended limit for environmental infrasound is L_{pG} = 85 dB.

Environment International. Vol. 23, pp. 519-527. *Cited in* Leventall, G. 2003, p. 34.

[63] Leventhall, G. 2003. p. 64.

[64] This International Standard specifies combinations of sound pressure levels and frequencies of pure continuous tones that are perceived as equally loud by human listeners. http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34222&scopelist=

- **Low Frequency Noise ($L_{pA,LF}$):** As seen on the chart below, the recommended limits for low frequency noise are 5-15 dB lower than the usual audible noise limits. Low frequency noise is assessed using a set of criteria which are separate from the criteria used with the overall "A" weighted noise level. To avoid possible underestimation of the frequency range, 16 – 20 Hz, the "A" weighting is used down to 10 Hz. Due to the excessive tolerances at low frequencies on the "A" weighting filter in the instrumentation standard (IEC 651), the "A" weighted level of the low frequency noise cannot be measured using a normal sound level meter supplied with a low-pass filter. The level must instead be synthesized from a narrowband frequency analysis by the addition of the nominal weighting function.[65]
- **Higher Frequency Noise (L_{pA}):** the normal A-weighting (dBA) is used for higher frequencies.

Table 2. Danish Noise Limits (Low Frequency and Audible Noise)

		Low frequency noise ($L_{pA,LF}$)	**Infrasound (L_{pG})**	**Usual/audible noise limit, (L_{pA})**
Rooms in dwellings, including childcare institutions, etc.	evening / night (6 p.m.–7 a.m.)	20 dB	85 dB	30 dB / 25 dB
	day (7 a.m.–6 p.m.)	25 dB	85 dB	30 dB
Offices, classrooms and other noise-sensitive rooms		30 dB	85 dB	40 dB
Other rooms in enterprises		35 dB	90 dB	50 dB

In the operation of the Danish limits, the noise is measured over at 10-minute period and a 5 dB penalty is added for impulsive noise. Although Denmark imposes a penalty for impulses, which are the main complaint of many sufferers,[66] none of the methods assess fluctuations. Broner and Leventhall (1983) suggest a penalty of 3 dB for noise that is fluctuating.[67]

In the United States, a standard for low frequency noise from wind turbines has been developed for the U.S. Department of Energy.[68] Also, some counties in northern Michigan have developed ordinances that reference low frequency noise as a separate than other noise issues.[69]

[65] Danish Environmental Protection Agency. 2002. *Danish Guidelines On Environmental Low Frequency Noise, Infrasound And Vibration.* (http://www.mst.dk/transportuk/02030000.htm#vibration)
[66] Leventhall, G. 2003, p. 72.
[67] Leventhall, G. 2003, p. 66.
[68] Kelley, N.D. 1987. *A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions.* Colorado: SERI, U.S. Dept.of Energy.
[69] Otsego County Planning Commission. 2004. *Land Use Issues of Wind Turbine Generator Sites. Section 3.* "Low frequency noise." (http://www.msue.msu.edu/cdnr/otsegowindlf**noise**.pdf)

FLUCTUATING OR INTERMITTENT NOISE

> *Fluctuating noises may be far more annoying than predicted by average sound levels.*[70]

Oil and gas pump jacks can create intermittent noises. Pump jacks may operate and automatically shut off for specific periods of time. When improperly maintained, pump jacks can develop rubbing noises or squeaking noises.

Regular variations of sound pressure levels with time have been found to increase the annoying aspects of the noise. Research suggests that variations at about 4 per second are most disturbing (Zwicker 1989). Noises with very rapid onsets could also be more disturbing than indicated by their LAeq,T (Berry 1995; Kerry et al. 1997).[71]

When machinery operates in cycles, or when single vehicles pass by, the noise level increases and decreases rapidly. For each cycle of a machinery noise source, the noise level can be measured just as for continuous noise. However, the cycle duration must be noted. A single machinery cycle or a passing vehicle is called an event.

Measuring fluctuating and intermittent noise
Sound level meters average noise readings over a period of time. This period is typically longer than the period of fluctuating or intermittent noises, which leads to a loss of information. *It underemphasizes the significance of fluctuating noises*.[72]

For intermittent noise, it is necessary to take into account both the maximum sound pressure level and the number of noise events.[73]

To measure the noise of an event, the Sound Exposure Level is measured, combining level and duration into a single descriptor. The maximum sound pressure level may also be used. A number of similar events can be measured to establish a reliable average.[74]

Penalties for fluctuating and intermittent noise
As mentioned above, when dealing with low frequency noise, Broner and Leventhall (1983) suggest a penalty of 3 dB for noise that is fluctuating.[75]

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[70] Leventhall, G. 2003, *p*. 36.
[71] Berglund, B., Lindvall, T. and Schwela, D. 1999.
[72] Wallula Power Project DEIS. Feb. 2002. Section 3.9: Noise, p. 3.9-1. (http://www.efsec.wa.gov/wallula/eis/DEIS/3.9Noise.pdf)
[73] Berglund, B., Lindvall, T. and Schwela, D. 1999. p. xii.
[74] Breul and Kjaer. 2000. *Environmental Noise Handbook,* p. 14.
[75] Broner, N., and Leventhall, H. G. 1983. "Low frequency noise annoyance assessment by Low Frequency Noise Rating (LFNR) Curves," *Journal of Low Frequency Noise and Vibration* Vol.2, pp. 20-28. *Cited in* Leventhall, G. 2003, p. 66.

IMPULSIVE NOISE

> *Impulsive noise. . . is brief and abrupt, and its startling effect causes greater annoyance than would be expected from a simple measurement of sound pressure level.*[76]
>
> ~ *Environmental Noise Handbook,* Breul and Kjaer

Impulsive sounds, such as gun shots, hammer blows, explosions of fireworks or other blasts, are sounds that significantly exceed the background sound pressure level for a very short duration. Examples of impulsive noise in the oil and gas industry could include venting and flaring, pipe-on-pipe impacts due to unloading pipe at a well site, and pile driving.

Measuring Impulsive Noise

Typically each impulse lasts less than one second. Measurements with a sound meter set to 'Fast' response do not accurately represent impulsive sounds. To cope with this, a third time constant called **I** (for impulse) has been developed. The time constant of I is 35 milliseconds, which is sufficiently short to permit detection and display of transient (rapidly changing) noise in a way resembling the human perception of sound.[77]

In Alberta, Canada, measurements of the A-weighted impulse response setting sound level measurement and the A-weighted slow-response setting sound level are taken. If the difference is 10 dBA or less, the impulsive sound is not deemed significant.[78]

Penalties for Impulses

The maximum penalty for impulsiveness varies from country to country, and both subjective (based on the type of source, using a list enumerating noise sources such as hammering, explosives, etc.).and objective methods are used to determine the penalty.

In Denmark, a 5 dB penalty is added for impulsive noise,[79] while in France a penalty of 3, 5 or 10 dB is assessed, depending on the duration of the impulsive noise.[80]

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[76] Breul and Kjaer. 2000, p. 14.
[77] http://www.norsonic.com/web_pages/sound_level_assessment.html
[78] Alberta Energy and Utilities Board (EUB). November, 1999. *Noise Control Directive User Guide*. (Guide 38). p. 64.
[79] Leventhall, G. 2003, p. 72.
[80] Breul and Kjaer. 2000, p. 32.

Appendix 2

City of Longbeach, California
Municipal Code

Title 12. Oil Production Regulations, Chapter 12.32 Noise

http://www.longbeach.gov/apps/cityclerk/lbmc/title-08/frame.htm

CHAPTER 12.32 NOISE

12.32.010 Excessive noise prohibited.
It is unlawful for any person to operate or cause to be operated any oil production or gas processing equipment on any well, or incidental to a well, within the incorporated limits of the city in any manner so as to create any noise which causes the exterior and interior noise level at the receiving property to be in excess of those limits provided in Chapter 8.80. (Ord. C-5935 § 2, 1983: Ord. C-5575 § 3 (part), 1980: prior code § 3300.38).

12.32.020 Areas 5, 7A, 7B, 8, 9, 12, 13, 16, 18, 19, 21, 22 and 23.
A. No person, either as owner, agent, or operator, shall conduct any drilling, or redrilling operation at any well located within oil operating areas 5, 7A, 7B, 8, 9, 12, 13, 16, 18, 19, 21, 22 and/or 23 in any manner so as to create any noise which causes the exterior noise level when measured at the property line of any single or multiple-family dwelling unit, guest room, commercial building, school, hospital, church, or public library to exceed the noise level standards set forth in Table 1. The exterior noise level generated by the drilling or redrilling operation shall be continuously monitored to ensure conformance to the noise level standards. The costs of such monitoring shall be borne by the operator conducting such operation.

Table 1.

Cumulative Number of Minutes In any One-hour Time Period	Noise Level Standards, dBA	
	Daytime 7:30 a.m. to 9:30 p.m.	Nighttime 9:30 p.m. to 7:30 a.m.
30	50	45
15	55	50
5	60	55
1	65	60
0	70	65

No person, either as owner, agent, or operator, shall conduct any drilling or redrilling operation at any time at any well located in oil operating areas 5, 7A, 7B, 8, 9, 12, 13, 16, 18, 19, 21, 22 and/or 23 in any manner so as to create any noise which causes the interior noise level in excess of those limits provided in Chapter 8.80.

If the existing ambient noise level, exclusive of existing drilling activity, at the nearest adjacent dwelling unit, guest room, commercial building, school, hospital, church or public library property line to the requested oil drilling site does not exceed the permitted nighttime noise levels in Table 1 for any period, then the following regulations shall apply:

1. The only activity permitted between the hours of nine-thirty p.m. and seven-thirty a.m. will be "on bottom" drilling, with single joint connections. None of the following will be done during the hours of nine-thirty p.m. and seven-thirty a.m.:
    a. Hammering on pipe;
    b. Racking of pipe;
    c. Acceleration and deceleration of engines or motors;
    d. Use of drilling assembly rotational speeds that cause more noise than necessary and could reasonably be reduced by use of a slower rotational speed;
    e. Picking up or laying down drill pipe, casing, tubing or rods into or out of the drill hole.

2. If the measured ambient level exceeds that permissible within any of the first four noise limit categories in Table 1 above, the allowable noise exposure standard shall be increased in five-decibel increments in each affected category as appropriate to encompass or reflect the ambient noise level. In the event the ambient noise level exceeds the fifth noise limit category, the maximum allowable noise level under said category shall be increased to equal the maximum ambient noise level.

3. If the difference between the noise levels with noise source operating and not operating is four decibels or greater, then the noise measurement of the alleged source can be considered valid with a correction applied to account for the contribution of the ambient noise. The correction is to be applied in accordance with data shown in Table 2.

Table 2. BACKGROUND NOISE CORRECTION

Difference Between Total Noise and Background Noise Alone (Decibels)	Amount to be Subtracted from Total Noise Measurement (Decibels)
4.0- 4.5	2.0
4.5- 6.0	1.5
6.0- 8.0	1.0
8.0-10.0	.5

The sound level meter used in conducting noise evaluations shall meet American National Standard Institute's Standard S1. 4-1971 for Type 1 or Type 2 sound level meters, or an instrument and the associated recording and analyzing equipment which will provide equivalent data. The acoustic terminology used in these sections shall be defined as in Section 8.80.020, and noise measurements procedure shall be conducted in compliance with methods specified in Section 8.80.140.

B. In the event that the owner, agent or operator conducting any operation which produces a noise level believed to be in excess of the noise levels provided in this section refuses or otherwise declines to shut down the drilling operation so that the ambient noise level can be measured, then the ambient noise level shall be estimated by performing a measurement in the same general area of the source but at a sufficient distance such that the offending noise from the source is inaudible.

C. If measurements conducted under subsections A or B of this section indicate a noise level in excess of that provided in subsection A, such drilling operation shall be deemed to be in violation of this section.

D. Violation of any provision of this section shall be cause for a notice of violation to be issued by the director. Thereafter, if the violation of any such condition or conditions of this section is not brought into compliance with this code, the director shall restrict the hours of operations to those hours between seven-thirty a.m. and six-thirty p.m. Monday through Friday, excluding city holidays. The procedure for violation provided in this section shall not be exclusive but shall be in addition to any other procedure for violation which the director can employ under the provisions of this title. (Ord. C-5575 § 3 (part), 1980: prior code § 3300.39).

12.32.030 Acoustical blankets.

A. No person, either as owner, agent or operator, shall conduct any drilling or redrilling operations on any well located within the oil operating areas 5, 7A, 7B, 8, 9, 12, 13, 16, 18, 19, 21, 22 and 23 unless all derricks and all drilling machines which produce noise and which are used in connection with said drilling or redrilling operations are enclosed with soundproofing material as provided in subsection B of this section.

B. When soundproofing is required by the provisions of subsection A of this section, such soundproofing shall comply with accepted A.P.I. standards and shall be subject to fire department regulations. All doors and similar openings shall be kept closed during

drilling operations, except for ingress and egress and necessary logging and well completion operations. Alternate materials or methods of soundproofing may be used, provided that such alternative has been approved by the director and the chief of the fire department. The director and the chief of the fire department may approve any such alternative if they find that the proposed material and method is equal to soundproofing ability and fire resistive qualities to the aforesaid specifications. Either may require the submission of evidence to substantiate any claims that may be made regarding the use of such alternative. (Ord. C-5575 § 3 (part), 1980: prior code § 3300.40).

12.32.040 Monitoring operations authorized.

For the purpose of noise abatement, the director shall have the authority to monitor the operation of oil field equipment used for drilling, redrilling, well servicing, remedial or maintenance work. (Ord. C-5575 § 3 (part), 1980: prior code § 3300.40).

APPENDIX 3

Alberta EUB Basic sound levels for nighttime hours (22:00 - 07:00).

Proximity to transportation	Dwelling unit density per quarter section of land		
	1 - 8 dwellings; dBA Leq	9 - 160 dwellings; dBA Leq	>160 dwellings; dBA Leq
Category 1	40	43	46
Category 2	45	48	51
Category 3	50	53	56

Terms Used in Table 2

Category 1	Dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
Category 2	Dwelling units more than 30 m but less than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
Category 3	Dwelling units less than 30 m from heavily travelled roads and/or rail lines and/or subject to frequent aircraft flyovers.
Dwelling Unit	Any permanently or seasonally occupied dwelling with the exception of an employee or worker residence, dormitory, or construction camp located within an industrial plant boundary. In the latter cases, occupational noise standards may be applicable.
Seasonally Occupied Dwelling*	A fixed residence with a conventional foundation that, while not being occupied full time, is occupied on a regular basis (approximately six weeks per year or more).
Density per 1/4 Section	Refers to a quarter section with the affected dwelling at the centre (a quarter mile/400 m radius). For quarter sections with various land uses or with mixed densities, the density chosen is then averaged for the area under consideration.
Heavily Travelled Roads	Any road where the average traffic count is at least 10 vehicles/hour over the nighttime period this generally includes primary and secondary highways.
Rail Lines	Includes any rail line where there is a minimum of one 25-car train passage during every nighttime period.
Frequent Aircraft Flyovers*	Dwellings that lie within a noise exposure forecast (NEF) 25 or greater contour, as designated by Transport Canada, require a site-specific analysis. In the absence of NEF contours for a local airport, Transport Canada is referenced for current air traffic statistics. To qualify for this adjustment, a dwelling must be within 5 km of an airport that has a minimum of nine aircraft takeoffs or landings over the nighttime period. See Noise Exposure Forecast in the Glossary (Appendix 1).

Appendix 4

Email correspondence from Anita Lewis, Operations & Compliance Branch, Alberta Energy & Utilities Board to Lisa Sumi, Research Director, Oil and Gas Accountability Project. August 3, 2005.

Appendix 5

Two examples of permit conditions attached to wells from Farmington, New Mexico. They include the 1 dBA over ambient noise standard.

Appendix 6

Email correspondence from Doug Walker, Noise Solutions, Inc., to Lisa Sumi, Research Director, Oil and Gas Accountability Project. August 2, 2005.