

Noise Impact Assessment
WOLF II Sanctuary
(West Larimer County Road 74E)

Prepared For:
WOLF
P.O. Box 1544
LaPorte, Colorado 80555
Voice: 970-416-9551

Prepared by: Stuart D McGregor
Stuart McGregor, PE

Table of Contents

Section number		Page Number
1	Introduction / Background	3
2	Applicable Noise Ordinance / Law	6
3	Analysis Methodology	8
4	Existing Background Sound Levels	12
5	Analysis Results	13
6	Mitigation Options	16
7	Conclusion	17
	Figure 1.1: WOLF II Property	18
	Figure 1.2: Proposed Site Layout	19
	Figure 3.2: Run Grouping for Analysis	20
	Figure 4.1: Location of Background Sound Level Measurements	21
	Figure 4.2: Existing Background Sound Levels, in Vicinity of Wolf Property	22
	Figure 5.3.1: West and Northwest Noise Contours	23
	Figure 5.3.2: South and Southeast Noise Contours	24
	Larimer County Noise Ordinance	25

1.0 Introduction / Background

This noise impact report was prepared for WOLF to assess the potential impact of the new WOLF II Sanctuary on nearby residences. The proposed site is located along the north side of Larimer County Road 74E, Figure 1.1 shows the location of the WOLF II property. Figure 1.2 shows a proposed site layout

1.1 Maximum Number of Wolves

Figure 1.2 shows the proposed maximum number of wolf enclosures is 30, with a maximum of 2 wolves per enclosure; maximum number of wolves is 60. Initially, the number of wolves will be less however, the modelling was performed assuming the maximum number of wolves.

1.1 Terrain

The site terrain is hilly, so that wolf enclosures can be placed such that,

Northwest – all residences in the Red Feather Highlands development (Northwest of Wolf) will not have a direct line of sight to any of the wolf enclosures and will have significant topography between the Wolf enclosures and the nearest Red Feather Highland's property line and residence. There is an existing BLM property between Red Feather Highlands and the Wolf property. Wolf noise levels were not calculated at the BLM property line or on the BLM property.

East – the wolf property is directly adjacent to the Wolf property, however, residences to the East will not have a direct line of sight to any of the wolf enclosures and the will have significant topographic barrier between the Wolf enclosures and the residences. Wolf noise levels were calculated at the eastern property adjacent property line and nearby eastern residences.

South and Southeast –

- a. There are three residences located on the north side of CR74E, that will have a nearly line of sight to some of the Wolf enclosures. These three residences will have the greatest noise impact.
- b. There are a number of residences south of CR74E which will have a nearly line of sight to some of the Wolf enclosures. These residences range from about ~1/2-mile to over 1-mile from the Wolf enclosures.

1.2 Nearest Residential Properties and Property Lines.

Distances from Wolf enclosures to nearby property lines and residences were taken from Figure 1.2 and scaled from Google Earth Pro. The properties or areas analyzed for Wolf sound levels are listed in Table 1.2. General descriptors regarding acoustical considerations between planned Wolf runs and nearby residences are,

Residences to the West – do not have a direct line of sight from the Wolf runs to the residences. The topography between the runs and the residences varies from minimal to significant.

Residences to the Northwest – there is significant distance and topography between the runs and all residences in the Red Feather Highlands Property, therefore, there is not direct line of site. There is also, significant vegetation between the runs and the residences.

East Property Line – there are four planned runs on the east side of the site which have a direct line of site to the east property line, with minimal vegetation.

Residences to the East – there is significant distance and topography between the runs and all residences to the east, therefore, there is not direct line of site. There is minimal vegetation between the runs and the residences.

Residences to the South – have a nearly direct line of site to five runs with minimal vegetation in between.

Southeast – have a nearly direct line of site to five runs with minimal vegetation in between.

Table 1.2: Residential Areas Analyzed

Residential Address or Property	Compass Direction from Wolf Runs	Approximate Distance from Residence of Closest and Furthest Run, feet
West Property Line	West	500
North Property Line	North	300
East Property Line	East	300 – 3,200
South Property Line	South	
17311 W CR 74E	West	2,400 – 5,200
142 Springmeadow Way	West Northwest	1,700 – 4,200
870 Springmeadow Way	Northwest	1,900 - 3,500
49 Springmeadow Way	Northwest	1,200 - 3,400
225 Parvin Court	Northwest	4,000 - 5,600
537 Drake Ranch Road	East	1,500 - 4,000
15458 Red Feather Lakes Road	East	1,900 - 4,600
15650 Red Feather Lakes Road	Southeast	1,600 - 4,800
15880 Red Feather Lakes Road	Southeast	1,800 - 4,200
16080 Red Feather Lakes Road	South	1,300 - 3,000
70 Mt. Tilleston Drive	South	2,000 - 4,000
119 Turtle Rock Court	South	3,200 - 4,900
56 Linsey Court	Southeast	5,800 - 8,000
121 Deadhorse Mountain Court	Southeast	6,000 - 8,500

1.3 Typical Noise Levels

Table 1.3 shows some A-weighted noise levels of typical activities. For the average human an increase of the measured noise level of 10 dB is Subjectively Perceived as being twice as loud or half as loud for a 10 dB decrease. The decibel change at which the average human will indicate that the noise is just perceptibly louder or perceptibly quieter is 3 dB, and a 1dB increase or decrease is not perceptible to the average person.

Measurement of community noise employs noise metric definitions that are, conceptually, ‘a’ noise level which is exceeded x percent of the time. For example the L_{max} is the maximum noise level sampled during the measurement period, the L₅₀ is the noise level that is exceeded 50 percent of the time (similar to the class average), and the L₉₀ is the noise level that is exceeded 90 percent of the time. The larger the L-sub percentage the lower the noise level in dB; i.e., the L₉₀ is always less than the L₅₀. The L₉₀ is considered to be the residual or true minimum background noise level. It is not appropriate to use the lowest sound level measured, at a specific location, as the background noise level, since, this minimum noise levels typically does not occur often.

A-weighted Noise Level (dBA) - the physical process of measuring sound with the same sensitivity to frequency as that of the human ear. A sound level meter will have, inside it, an electrical circuit that allows the meter to have the same sensitivity (response) to sound at different frequencies as the average human ear. Noise ordinances and law are typically written in terms of dBA.

Ambient Noise - at a specified time, the all-encompassing sound associated with a given environment, being usually a composite of sound from many sources at many directions, near and far, including the specific sources of interest.

Background or Residual Noise - at a specified time, the all-encompassing sound associated with a given environment, being usually a composite of sound from many sources at many directions, near and far, remaining in a given location in a given situation when all uniquely identifiable discrete sound sources are eliminated, rendered insignificant, or otherwise not included.

Energy Equivalent or Average Level (Leq) - a constant sound level over the entire measurement period that contains as much sound energy as the actual time-varying sound level. During a sample period the noise level fluctuates up and down, if we were to perform an energy average of the fluctuating levels throughout the sample period (i.e.; find the area under the curve), the Leq is simply equal to the constant noise level, over the same time period, that would have the same area under the curve.

Day-Night Average (DNL) - is the logarithmic average of the daytime (7am to 10pm) and the nighttime (10pm to 7am) Leq's, with a ten dB(A) penalty added to the nighttime Leq.

Table 1.3: Qualitative Description of Typically Occurring Noise

Sound Level, dB(A)	Type of Noise	Relative Loudness (Human Judgement) of Different Noise Levels	Subjective Impression of Noise
110	Disco Dance Floor	128 times as loud	Uncomfortably Loud
90	Motorcycle at 25'	32 times as loud	Very Loud
85	D8 Cat Dozer at 50 ft.		
80	Diesel Truck, 40 mph at 50'	16 times as loud	Loud
75	Average Car, 40 mph at 25'		
70	Vacuum Cleaner at 3'	8 times as loud	
65	Conversation at 3'		
60	Background Music	4 times as loud	
55	Air Conditioning Unit at 15'		
50	Quiet Residential	Twice as loud	
45	Bird Calls		Quiet
40	Lower Limit Urban Daytime Ambient	Reference loudness	
30	Background Quiet Suburban at Night	1/2 as loud	
20	Quiet Whisper	1/4 as loud	Barely Audible
0	Threshold of Hearing		

2.0 Applicable Noise Ordinance / Laws

Larimer County Noise Ordinance No. 97-03 limits noise levels from one residential property to another residential property to,

55 dBA during the daytime (7:00am to next 7:00pm) and

50 dBA during the nighttime (7:00pm to next 7:00am).

NOTE: See more complete version of 97-03 on at the end of this report.

Compliance with Section 6a is measurable with sound level meters while Section 6d is not. Section 6d uses the phrase “unreasonable interference” which can be interpreted to mean “annoyance” which has been addressed by the EPA, covered in several books on acoustics and in numerous reports and publications. A brief review of these works follows:

1. U. S. Environmental Protection Agency Office of Noise Abatement and Control, March 1974. “Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety”, No. 550/9-74-004. The EPA document does not specifically address the noise from animals, rather it addresses typical community noise such as traffic and aircraft.
2. Kryter, Karl D.: The Effects of Noise on Man. 1985, Academic Press, Inc., Chapter 11, pp526 through 608. This chapter addresses “Annoyance” and in general shows that if the noise of aircraft or traffic is less than an DNL of 55 dBA, adverse community reaction will be minimal. On page 568, Table 11-10 shows that for an asphalt quarry producing an DNL of 64 dB(A), a reaction of “Threats of Legal Action” occurs. An DNL of 64 is 14 dB higher than the maximum nighttime limit for the Wolf Sanctuary. Also, Table 11-10 shows wide spread complaints would occur for a cement plant producing an DNL of 56 resulted in “No Observed Reaction”. In general, Kryter shows that an DNL of 55 dB(A) or less from a variety of noise sources is an acceptable level for residential areas.
3. Acoustical Society of America (ASA) Publication in the “Journal of the Acoustical Society of America”. A search of the ASA Journal produced 644 articles addressing annoyance of noise most of which involved aircraft and traffic noise. This entire listing of the 644 articles may be obtained on the ASA web site titled “Acoustical Society of America Digital Library”.
4. Schultz, Theodore J.: Community Noise Rating, 1972, Applied Science Publishers, ISBN 0-85334-137-0. Chapter 6 addresses “Noise Annoyance” and as with other researchers the threshold of annoyance for jet aircraft and traffic noise is 55 DNL.
5. Harris, C. M., ed 1998. Handbook of Acoustical Measurements and Control, McGraw Hill, Chapter 23, “Noise Induced Annoyance of Individuals and Communities”. This chapter is an extensive treatment of annoyance. Figure 23.1 indicates that about 10% of a population exposed to 55 dB(A) will be annoyed. The author of this chapter cites numerous references on the subject of annoyance. A discussion of the information presented in this reference is presented herein.

In Chapter 24 of Harris’s book titled “Human Performance and Noise” the chapter authors, Jones D.M. and Broadbent D.E. dedicate twenty pages and 106 references to the subject. On page 24.3 under the heading “Changes in Sound Level” the authors write:

If a noise is expected and familiar, it is very unlikely to produce any impairment of efficiency. This is particularly true if the task is undemanding: if the person has to react only at certain definite times, receives a clear warning of the need for reaction, and receives an easily visible stimulus, noise will show no effect.

In other words, the authors are saying that noise, which is familiar, becomes less intrusive as time goes by. As an example; vehicle traffic on rural roads, the sound from vehicles passing by may be clearly audible, however, for people living in these areas the vehicle traffic becomes subjectively less obtrusive over time.

On page 24.13 under the heading, "Time of Day Arousal" the authors write: *In its effects on performance, sleep loss has the opposite effect of noise, since when they are present together, the effect of each in isolation appears to be canceled out.*

One paper presented at the May 1997, 133rd meeting of the Acoustical Society of America; paper 4PAB6, Canine Acoustics. II. Frequencies, transmission and annoyance addressed the noise from Eastern Coyotes. In that paper it was reported that investigators had measured noise level of coyotes to be 93 dB, however distance from the animal to the measuring instruments was not reported.

3.0 Analysis Methodology and Wolf Noise Levels

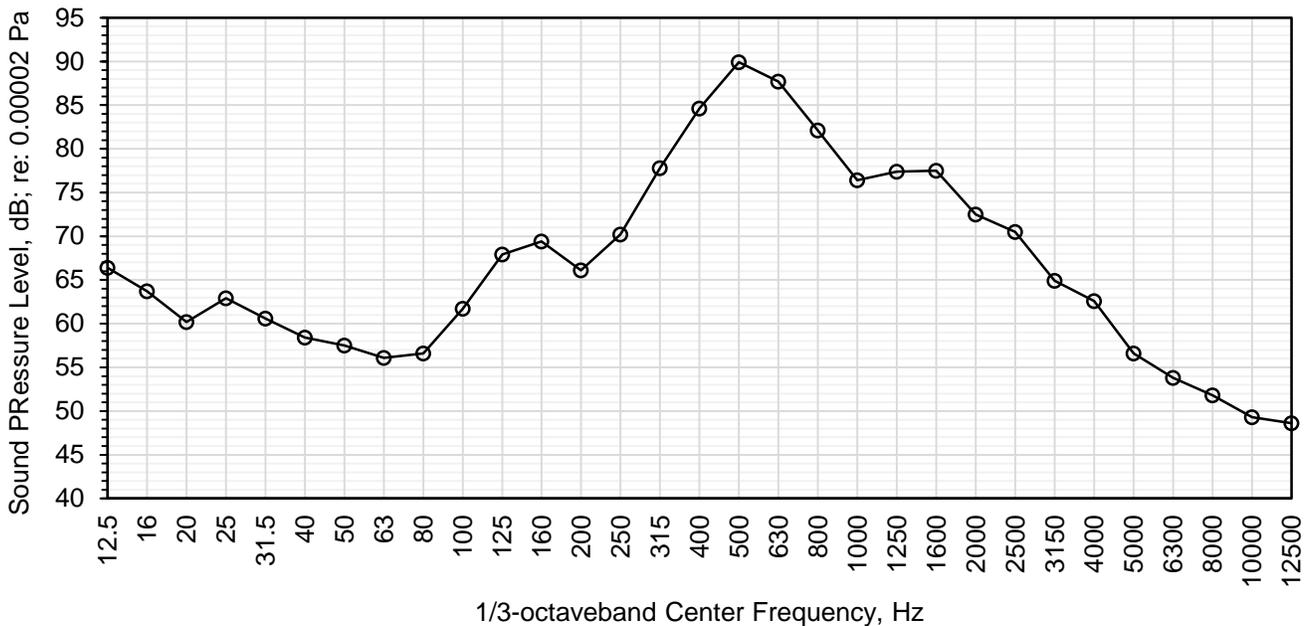
The predicted Wolf barking and howling noise levels at nearby residential property lines and residences were calculated using standard acoustical engineering equations and assumptions as described below.

3.1 Wolf Barking and Howling Noise Levels

Wolf barking and howling noise levels were measured, at the existing Wolf Sanctuary, by stimulating wolves to bark and howl. The resulting barking and howling spectrums were combined to generate a 'typical' maximum single wolf noise emission level. This data was averaged and then a distance correction was applied to calculate the 'typical' maximum Wolf noise power emission level; for one wolf. This typical sound power emission level is shown in Figure 3.1. Wolf barking and howling sound pressure levels were converted into sound power levels to facilitate the calculation process at difference wolf (source) locations and for multiple wolves.

Aside: the sound power emission level of a sound source is directly analogous to the wattage rating of an incandescent light bulb. When the observers is close to the light bulb it is bright when the observer is far away it is not as bright, however, the power output of the light bulb has not changed. So for a sound source, the sound power level is the same whether the observer is close to the source or far away. What changes with increased distance is the measured or heard sound pressure level. Up close a lawn mower may be 90 or 95 dBA while 100 feet away the lawn mower may be 50 or 55 dBA; however, the sound power output of the lawn mower has not changed.

Figure 3.1: Wolf 'Typical' Maximum Barking and Howling, Sound Power Level, Single Wolf



3.2 Analysis Methodology and Assumptions

Equations and parameters used in this analysis were taken from, 'Handbook of Acoustical Measurements and Noise Control', 3rd Edition, Cyrill Harris, McGraw-Hill, Chapter 3 – Sound Propagation in the Open Air.

ANSI S1.26-2009, American National Standard, Method for Calculation of the Absorption of Sound by the Atmosphere; Air Temperature +5°C.

Effects of Vegetation – the effects of vegetation on attenuation of noise is fairly minimal. To provide any significant sound attenuation requires 'fairly' dense and tall vegetation for a reasonable distance or a 'long' path through the vegetation. The only significant vegetation on and around the site are pine trees, with little or no attenuation from the Wolf enclosures to the east, south and southeast. For residences to due west, south and southeast, attenuation from vegetation was considered to be zero. For residences in the Red Feather Highlands there is enough vegetation for consideration; however, for this analysis attenuation levels were limited to no more than 3 dB at any given analysis frequency.

Topography – between Wolves (sound sources) and the property lines or residences (sound receptors) was modelled as thick sound barriers. The height of the barriers was calculated based on the elevation of the receptor, the maximum elevation of the topography between the Wolf enclosure and the receptor, and the average elevation of the enclosure. When wolves are at low portions of the enclosures, the effective barrier height will be greater and expected sound attenuation from topography will be greater than modelled; yielding lower predicted Wolf sound levels. Elevations of Wolf enclosures, intervening topography and nearby residences and residential property lines was obtained from using Elevation Profiles from Google Earth Pro.

Wind Conditions – direction of the wind between the noise source and the noise receptor(s) will, increase noise levels with wind direction from noise source to noise receptor, and decrease noise levels with wind direction from noise receptor to noise source. No wind effects were taken into account in the analysis; however, since, the dominant wind direction in the vicinity of the Wolf site is from north to south or northwest to southeast, it is expected that predicted noise levels at Red Feather Highlands will be lower than shown by 1 to 5 dBA, (depending on wind speeds) and predicted noise levels for residences to the south, southeast and east will be higher than shown by 1 to 5 dBA (depending on wind speeds). When wind speeds exceed 20 mph atmospheric turbulence and wind noise through the trees will increase the background sound levels to the 40 dBA, range.

For example; when the wind direction is from the Wolf enclosures towards a residence, Wolf sounds at the residence will increase and then as wind speeds increase further, background sound levels will begin to mask and hide Wolf sounds.

Number of Wolves – Figure 1.2 shows the proposed maximum number of wolf enclosures is 30, with a maximum of 2 wolves per enclosure; maximum number of wolves is 60. Initially, the number of wolves will be less however, the modelling was performed assuming the maximum number of wolves.

Wolf Distribution – Figure 3.2 shows have the Wolf runs were divided into Groups of runs for the analysis process. The grouping was chosen based on proximity between runs, location on the site, and surrounding topography.

Sound Level Calculation Procedure – used to predict Wolf barking and howling noise levels and noise receptors was as follows,

- a. Starting with combined maximum single Wolf barking and howling Sound Power Level spectrum, as shown in Figure 3.1, which was adjusted based on the maximum number of wolves in each Group.
- b. Then the following attenuation effects were applied (on a frequency basis, to each 1/3-octave band),
 - Distance attenuation using standard $1/r^2$ geometric divergence,
 - Topographic attenuation (barrier effects),
 - Atmospheric attenuation,
 - Ground absorption,
 - Vegetation effects (as described above),
 - Noise source height (3-feet above ground),
 - Noise receptor height (5-feet above ground),
 - No wind effects, and
 - Atmospheric conditions (+40°F and 20% Relative Humidity)
- c. After applying attenuation effects to the source SPL data. The resulting spectrum was A-weighted and logarithmically summed to generate the overall A-weighted Sound Pressure Level (SPL), for each Group for each sound receptor.
- d. The resulting overall A-weighted SPL is then used to assess noise impacts (if any) and the level of Wolf barking and howling audibility.
- e. Assumptions on number of Wolves barking or howling at any given time would be that all or nearly all the Wolves would howl at nearly the same time. All the Wolves will never howl or bark at exactly the same moment in time, therefore, the predicted Wolf noise levels are a maximum worst case condition. Additionally, Wolf howls or barks are discrete events and do not occur continuously, discussions with Wolf personnel indicate that the wolf howls or barks occur 5 to 10 times a day. With durations which range for a few seconds to a few minutes. Therefore, the Wolf howls or barks occur approximately 1-percent or less of the day.
- f. Attenuation from outside to inside residences. The level of sound attenuation from outside a building to inside a building is completely dependent on the building construction, especially, the level of sound attenuation provided by the windows. The assumption for noise attenuation from outside a residence to inside a residence used in this analysis, is that occupants of a residence are not standing at the window opening, and are some distance inside the building. Additionally, the attenuation levels used are lower than would typically, be used; safety factor, and are,
 - With Windows Open – 10 dBA, and
 - With Windows Closed – 20 dBA.

3.3 Commonly Misused Acoustical Terms used in Environmental Noise Conditions

There are a number of acoustical terms / phenomena which are misunderstood when considering environmental noise sources; such as, reflections, echoes and reverberation.

Reflections – sound does reflect off hard surfaces such as rock, concrete, drywall, etc. However, sound reflects off a hard surface analogously to how a billiard ball bounces off a bumper. The angle of incidence equals the angle of reflections. All the topography on the Wolf property is angled and not vertical so sound from a Wolf will reflect off the topography up into the atmosphere to be absorbed. Additionally, there is very little surface area on the Wolf property which is a flat hard reflecting surface, most of the topography is covered with grass and the rocks which are present, are rounded and have trees nearby, all of which tends to absorb or dissipate sound waves.

Echoes – sound does echo off rock walls, as it does in the Grand Canyon. However, there are not large parallel rock surfaces on the Wolf property between which sound can echo. In areas where echoes occur, the sound pressure level of the echo is always less than the initial sound level.

Reverberation – only applies to spaces which are enclosed; inside rooms or in a cave. This term has no meaning for the topography of the Wolf property.

None of these 'so-called' "focusing effects" will or can occur of the hillsides and topography of the Wolf property.

4.0 Existing Background Sound Levels

As part of this analysis background sound level measurements were made on the Wolf property. The measurement location is shown in Figure 4.1, and was chosen to minimize noise impact from existing noise sources in the area; specifically, vehicle traffic on CR74E. The measurement location provides representative background sound levels in general vicinity around the Wolf site, including Red Feather Highlands, Glacier Meadows, etc, **when and only when** there is no vehicle traffic on CR74E, winds are less than 10 mph, and minimal other human activity is present.

Background measurements were taken with a Quest Model 2900, Type 2, Logging Sound Level Meter. The meter was configured as follows, A-weighting, Slow Time Constant and Logging 1-min Leq's. The measurement period was from 11:15am Thursday May 11 through 7:45am Wednesday May 17.

Results of the background measurements are shown in Figure 4.2. The x-axis in Figure 4.2 is time on a 24-hour clock. Analysis of this data is listed in Table 4.1.

Table 4.1: Background Sound Levels, on Western Portion of Wolf Property

Sound Level Descriptor	Sound Level Descriptor	Sound Level, dBA
Leq	Average sound energy over the entire measurement period	38
L10	10 percent of the time sound levels are greater than this level	40
L50	50 percent of the time sound levels are greater than this level	30
L90	90 percent of the time sound levels are greater than this level	28
L99	99 percent of the time sound levels are greater than this level	27

The background sound levels shown in Figure 4.2 and Table 4.1 are interpreted in the context of the Wolf property and the surrounding residential properties as follows.

First – the measured background sound levels are similar to sound levels measured, by EDI, in other semi-mountainous areas in Colorado.

Second – these sound levels are representative only for properties and residences which DO NOT have a direct line of sight to CR74E. For residential properties and residences which do have a direct line of sight to CR74E existing sound levels will be greater due to traffic on CR74E. The closer the residential properties or residences is to CR74E the greater then increase. For residences within 300 feet of CR74E, vehicle traffic from will be greater than 50 dBA.

Third – the 30 dBA range background sound levels do not exist when wind speeds are above 15 or 20 mph or when other human activities are present. These activities include, construction, aircraft overflights, dog barking, etc.

Note: the sound spikes in Figure 4.2, are transient sound events; birds chirping, leaves rustling, airplanes, etc. The results are typical for this type of environment.

5.0 Analysis Results

5.1 Traffic Noise

Traffic noise impact from the proposed Wolf facility has been evaluated on based on comparing existing vehicle traffic counts on CR74E and predicted traffic increase from Wolf operations. Traffic vehicle count data was obtained from the Delich Associates preliminary traffic analysis dated 4-Oct-16. Table 5.1 shows Average Annual Daily Traffic (AADT) counts for 2015 (Larimer County Data), 2016 Wolf Measured and 2022 Time Frame Projected. Also, shown in Table 5.1 are the projected Wolf Phase 1 and Phase 2 daily trip count (Wolf trip count is the sum of both vehicles coming to and leaving Wolf) and the sound level increase from Wolf facility traffic added to CR74E non-Wolf traffic.

Increased vehicle traffic on CR74E from Wolf operations, at Phase 2 buildout, will be less than 1 dBA. This sound levels increase is not perceptible to the average person; see Section 1.3 of this report. Therefore, vehicle increases on CR74E from Wolf facility operations will yield an average sound level increase which is not perceptible to the average person.

Table 5.1: Sound Level Increase Wolf Traffic Volume Increase on CR74E and

Time Frame	CR74E Non-Wolf Related Traffic Counts, vehicles / day	CR74E Wolf Related Traffic Counts, vehicles / day	Average Sound Level Increase, dBA
2015	1800	0	0
2016	1493	52, Phase 1	0.1
2022	1668	124, Phase 2	0.3

5.2 Wolf Sound Impacts

Table 5.2.1 shows the calculated worst case maximum Wolf barking and howling sound levels, outside the residences, inside residences with windows open and inside residences with windows closed.

Inspection of Tables 5.2.1 shows,

- a. That maximum Wolf sound levels Comply with both the Larimer County Noise Ordinance, Number 97-03, Daytime and Nighttime noise limits of 55 and 50 dBA, at the Western and Eastern Property Lines.
- b. That maximum Wolf sound levels Comply with the Larimer County Noise Ordinance, Number 97-03, Daytime noise limits of 55, at the north property line. Since, this land is unoccupied BLM property it is not zoned, and therefore, the Daytime noise limit is used as a compliance criteria.
- c. That maximum Wolf sound levels Comply with both the Larimer County Noise Ordinance, Number 97-03, Daytime and Nighttime noise limits of 55 and 50 dBA, at all nearby residences, and are significantly below the Larimer County Nighttime noise limit.

Table 5.2.2 shows predicted level of audibility at the receptors listed in Table 5.2.1, outside, inside with windows open and inside with windows closed. Assessment of Audibility of Wolf sound is rated based on the existing background sound levels in the area and the level of Wolf sound. The data presented in Section 4.0 of this report showed that the existing background sound levels in area of the Wolf property and surrounding properties, without direct line of sight to CR 74E is in the range of 27 to 30 dBA. For residences and properties with direct line of sight to CR 74E vehicle traffic sound levels exceed the 30 dBA level.

Audibility is assessed based on the difference between the background sound and the sound in question; in this case Wolf howl or bark sounds. The assessment of audibility is as follows,

Clearly Audible – Wolf sounds are within 5 dBA of the background sound levels.

Slightly Audible – Wolf sounds are about 10 dBA less than background sound levels.

Barely Audible – Wolf sounds are 15 dBA less than background sound levels.

Inaudible – Wolf sounds are more than 15 dBA less than background sound levels.

NOTE: inside residences if the radio or television is on or conversation is taking place, sounds levels will be significantly higher than the outdoor background sound levels, which will significantly reduce the audibility rating of Wolf sounds.

Table 5.2.1: Predicted Maximum Wolf Sound Levels

Residential Address or Property	Predicted Exterior Wolf Sound Levels, dBA	Predicted Interior Wolf Sound Levels with Windows Open, dBA	Predicted Interior Wolf Sound Levels with Windows Closed, dBA
West Property Line	24	NA	NA
North Property Line	53	NA	NA
East Property Line	47	NA	NA
South Property Line	40	NA	NA
17311 W CR 74E	21	11	<5
142 Springmeadow Way	11	<5	<5
870 Springmeadow Way	13	<5	<5
49 Springmeadow Way	13	<5	<5
225 Parvin Court	11	<5	<5
537 Drake Ranch Road	11	<5	<5
15458 Red Feather Lakes Road	13	<5	<5
15650 Red Feather Lakes Road	28	18	8
15880 Red Feather Lakes Road	26	16	6
16080 Red Feather Lakes Road	36	26	16
70 Mt. Tilleston Drive	33	23	13
119 Turtle Rock Court	32	22	12
56 Linsey Court	23	13	<5
121 Deadhorse Mountain Court	22	12	<5

Table 5.2.2: Predicted Audibility of Wolf Sounds

Residential Address or Property	Predicted Exterior Wolf Sound Levels, dBA	Predicted Interior Wolf Sound Levels with Windows Open, dBA	Predicted Interior Wolf Sound Levels with Windows Closed, dBA
West Property Line	Audible	NA	NA
North Property Line	Audible	NA	NA
East Property Line	Audible	NA	NA
South Property Line	Audible	NA	NA
17311 W CR 74E	Slightly Audible	Inaudible	Inaudible
142 Springmeadow Way	Inaudible	Inaudible	Inaudible
870 Springmeadow Way	Inaudible	Inaudible	Inaudible
49 Springmeadow Way	Inaudible	Inaudible	Inaudible
225 Parvin Court	Inaudible	Inaudible	Inaudible
537 Drake Ranch Road	Inaudible	Inaudible	Inaudible
15458 Red Feather Lakes Road	Inaudible	Inaudible	Inaudible
15650 Red Feather Lakes Road	Audible	Slightly Audible	Inaudible
15880 Red Feather Lakes Road	Audible	Barely Audible	Inaudible
16080 Red Feather Lakes Road	Audible	Slightly Audible	Barely Audible
70 Mt. Tileston Drive	Audible	Slightly Audible	Inaudible
119 Turtle Rock Court	Audible	Slightly Audible	Inaudible
56 Linsey Court	Slightly Audible	Barely Audible	Inaudible
121 Deadhorse Mountain Court	Slightly Audible	Barely Audible	Inaudible

5.3 Noise Contours

Figures 5.3.1 and 5.3.2 show predicted Wolf noise contours, outside levels, towards the West and Northwest, and the East, South and Southeast. The accuracy of the noise contours is not less than ± 100 feet.

Interpretation of the noise contours is as follows,

- a. Closer to any Wolf enclosure from the noise contour Wolf sound levels will be greater.
- b. Further from any Wolf enclosure from the noise contour Wolf sound levels will be less.

6.0 Noise Mitigation Options

Results of the noise analysis showed that the residences / properties with any measureable noise impact are; one, the property directly west of the site on the south side of CR 74E and residences to the south / southeast of the site, particularly those along the north side of CR 74E. Therefore, any noise mitigation either in the form of physical barriers or Wolf operating procedures should be directed towards these residences.

Since, the sound impact from the Wolf Sanctuary will be sound events

6.1 Physical Noise mitigation

The distribution of Wolf enclosures / runs over large areas and the topographic relief of the development site, limit locations where physical noise barriers can be install and provide some level of effectiveness. The only location on the property where physical noise mitigation is feasible and will generate the greatest level of noise reduction is along the South and East sides of enclosures 1, 2, 3 and V1. Building the access road will generate significant amounts of rock and soil, which can be relocated to enhance the natural topography and create new topography between these wolf enclosures and the residences to the South and Southeast. The extent and height of these noise barriers will have to be addressed during the final site planning process. At which time the level of noise mitigation achieved can be assessed.

6.2 Procedural Noise Mitigation

Procedural noise mitigation, is the process of setting up written procedures / guidelines for Wolf operations. Options are listed below,

- a. Locate Wolves, which are less vocal or have quieter vocalizations, in enclosures which have greatest exposure to nearby residences; enclosures 1, 2,3, 27, V1 and V2.
- b. Delay morning feed times, when Wolves have high rates of vocalization, to later morning hours; 9 to 10 am.
- c. Minimize human activities near Wolf enclosures which cause Wolf vocalization.

7.0 Conclusions

The proposed Wolf II Sanctuary complies with Larimer County Noise Ordinance, Number 97-03, Daytime or Nighttime noise limits of 55 and 50 dBA at the nearest Wolf property lines and at all nearby residences.

Wolf barking and howling will be,

Residences to the West – slightly audible outside the residence, barely audible inside the residence with the windows open and inaudible inside the residence with the windows closed.

Residences to the Northwest – inaudible to barely audible outside the residence and inaudible inside the residences with the windows open or closed windows.

Residences to the East – inaudible outside and inside the residences.

Residences to the South – audible outside the residence, barely audible inside the residence with the windows open and inaudible inside the residence with the windows closed.

Residences to the Southeast – audible to slightly audible outside the residence, Barely to Slightly audible inside the residence with the windows open, and inaudible with the windows closed.

Additionally, it is important to note that Wolf howling or barking, that is Clearly, Slightly or Barely audible, sounds occur will occur on the order of 1 percent or less of a typical day. During times of the year when temperatures are lower and residence windows are closed Wolf sounds will be inaudible inside all nearby residences, except residences on the North side of CR74E where Wolf sounds will be Barely audible.

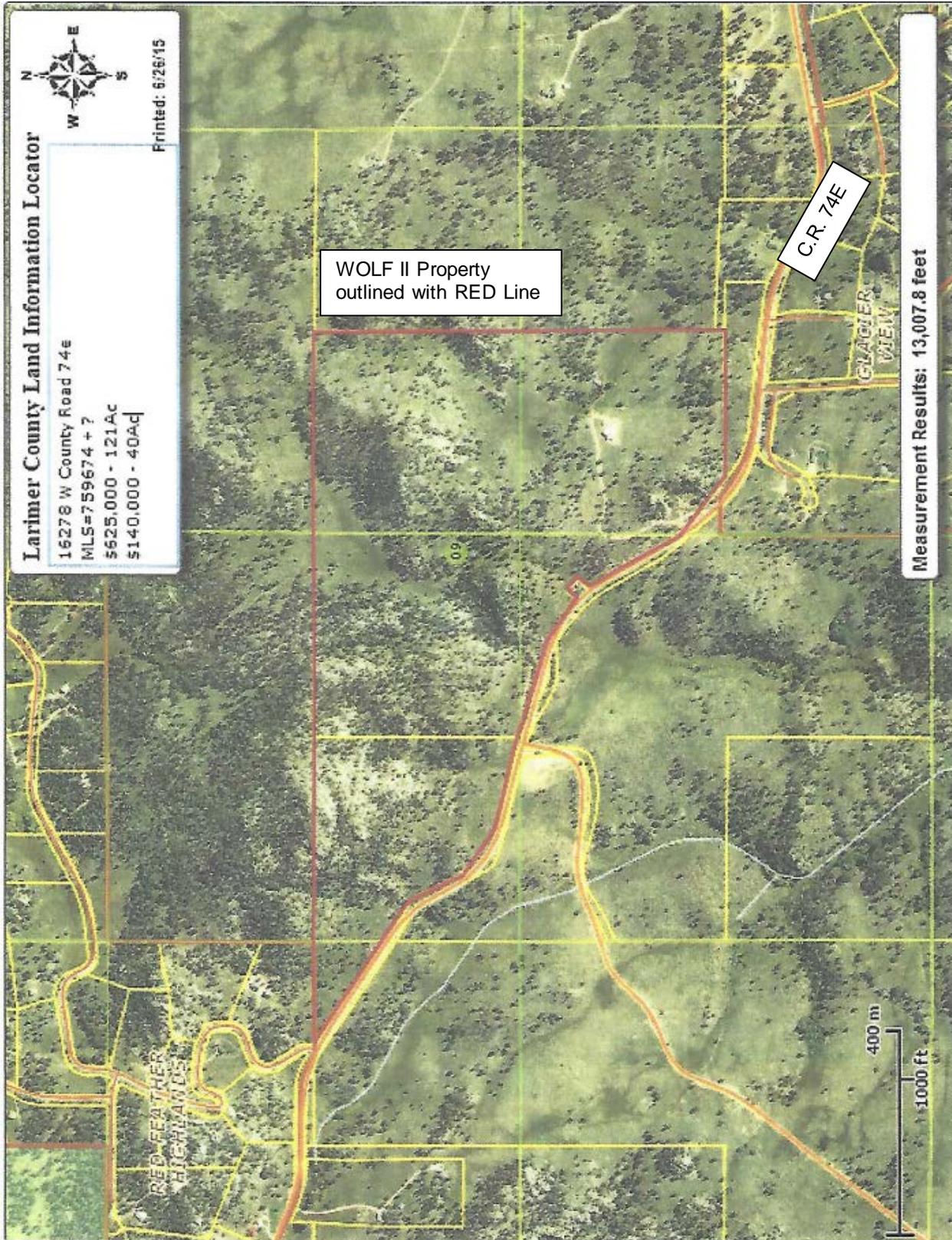


Figure 1.1: WOLF II Property

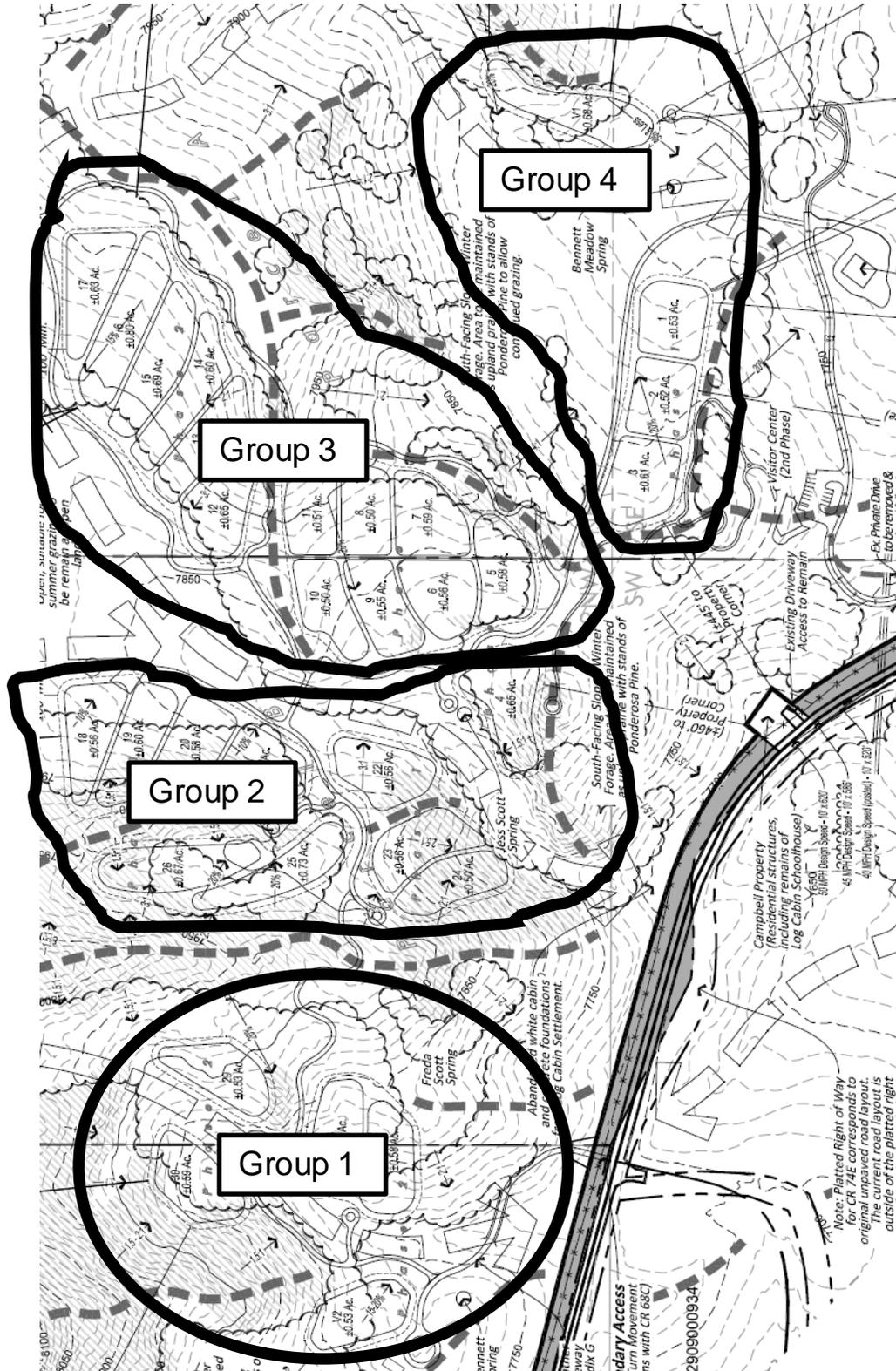


Figure 3.2: Run Grouping for Analysis

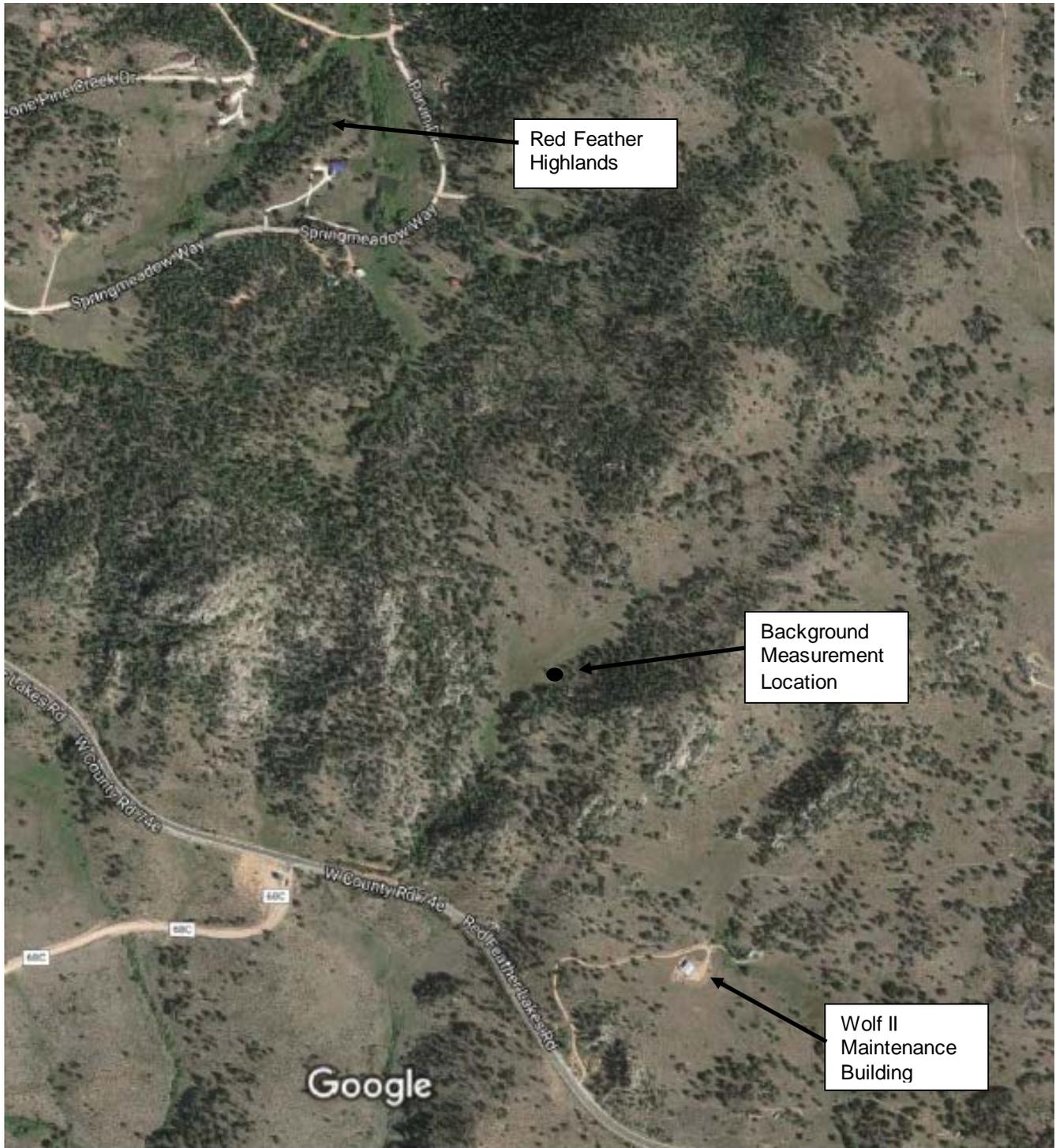
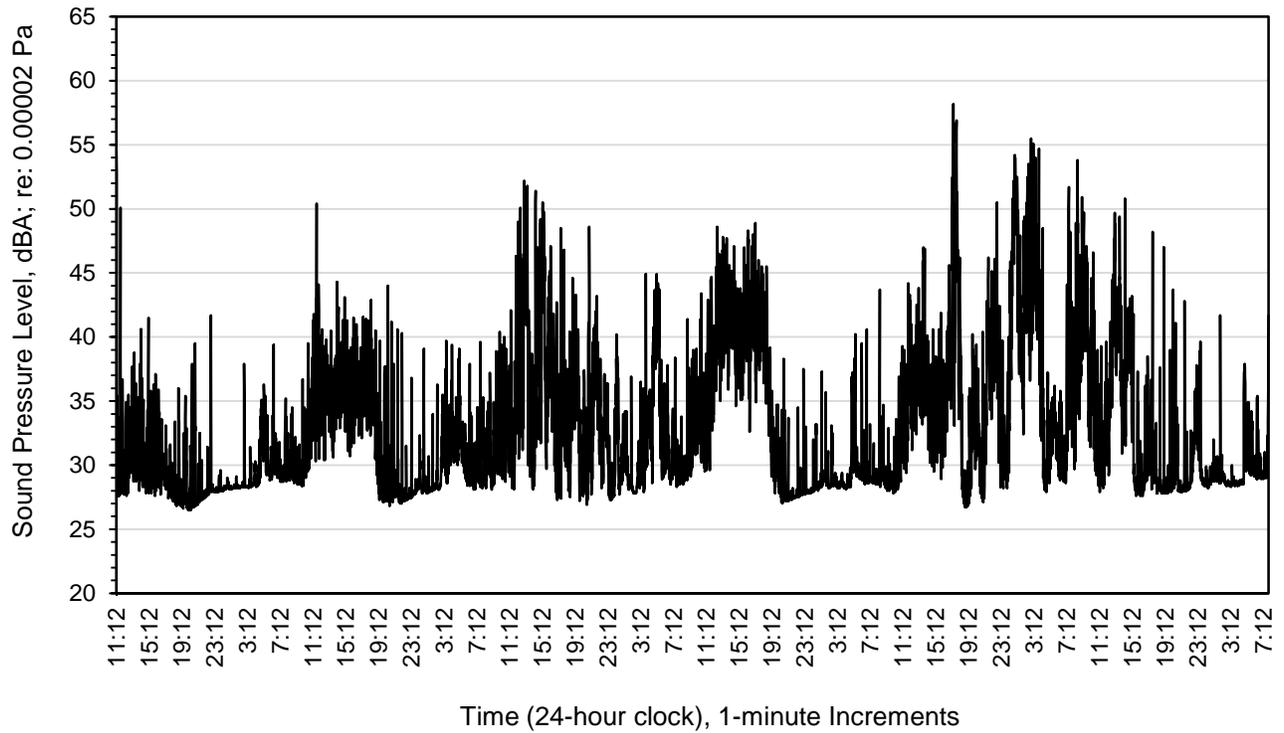


Figure 4.1: Location of Background Sound Level Measurements

Figure 4.2: Existing Background Sound Levels, in Vicinity of Wolf Property



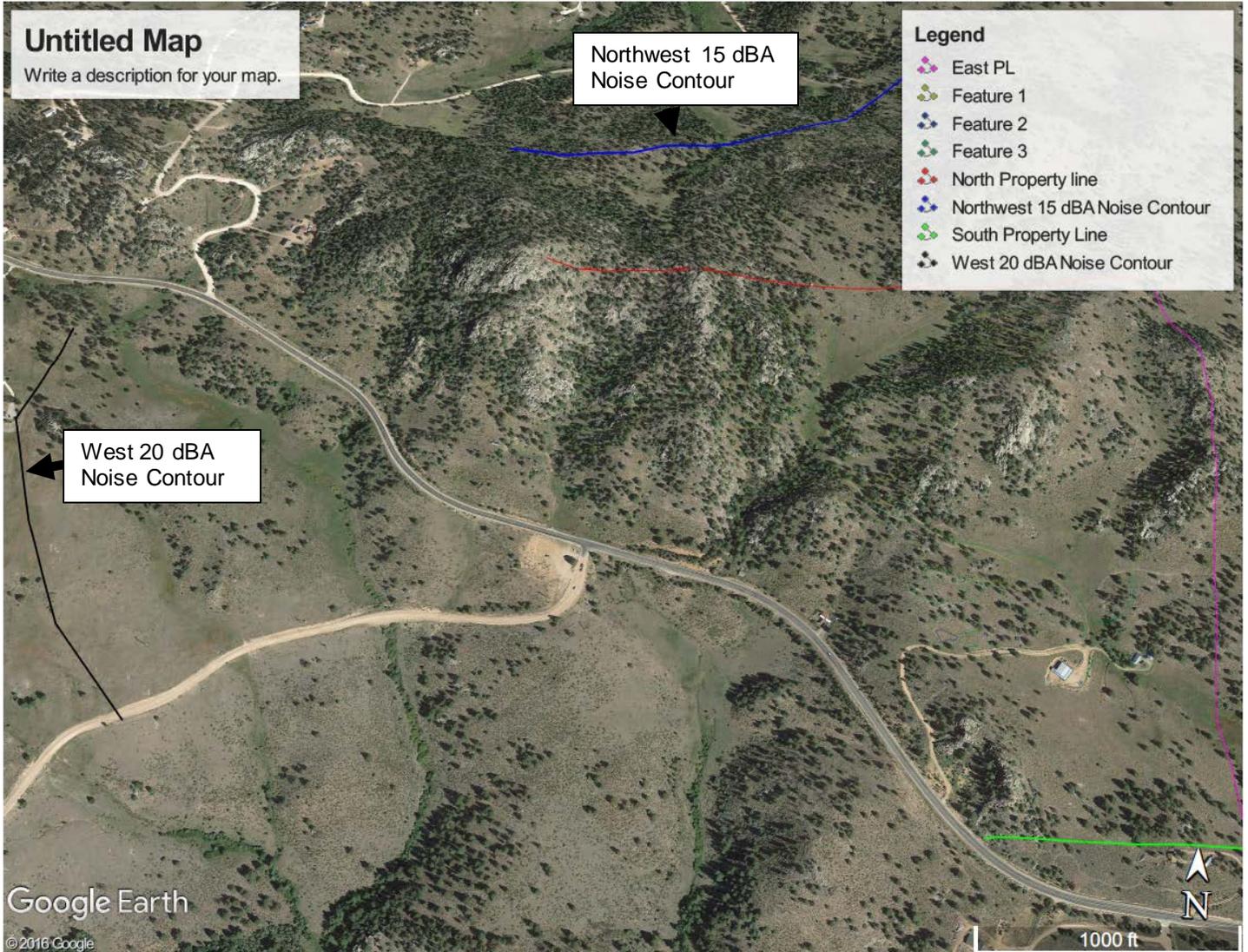


Figure 5.3.1: West and Northwest Noise Contours

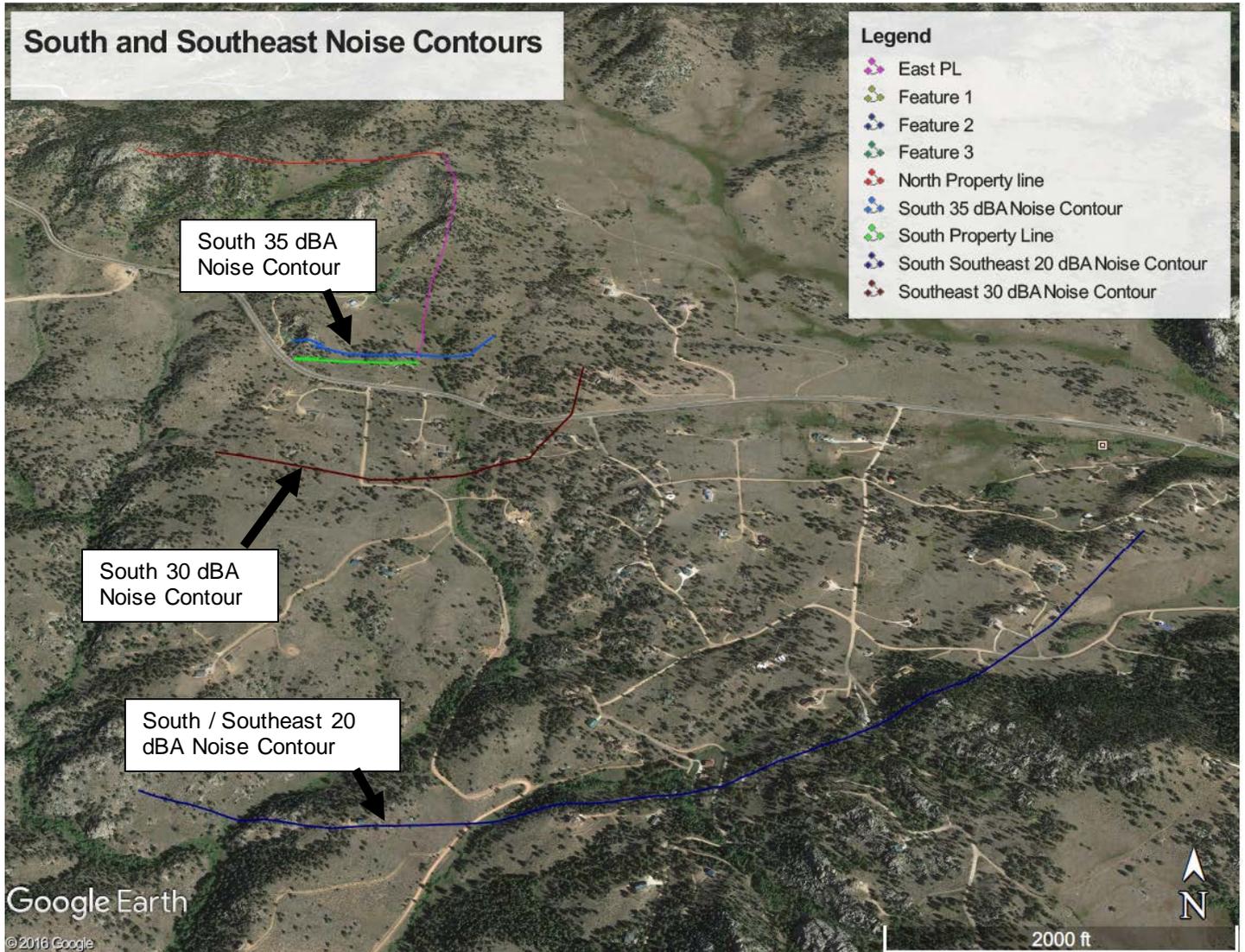


Figure 5.3.2: South and Southeast Noise Contours

ORDINANCE CONCERNING NOISE LEVELS IN UNINCORPORATED LARIMER COUNTY
Ordinance No. 97-03

Section 1. Purpose:

The Board of County Commissioners of Larimer County, Colorado, finds and declares that noise in excess of the limits provided in this Ordinance is a major source of environmental pollution which represents a threat to the serenity and quality of life in Larimer County, and excess noise often has an adverse physiological and psychological effect on human beings, thus contributing to an economic loss to the community.

Section 2. Scope Of Ordinance:

This Ordinance shall apply within the unincorporated territory of Larimer County.

Section 3. Definitions:

The following definitions shall apply to this Ordinance:

- c. "Noise Disturbance" means any sound which is or may be:
 - 1. Harmful or injurious to the health, safety or welfare of any individual; or
 - 2. Of such a volume, frequency and/or intensity that it unreasonably interferes with the enjoyment of life, quiet, comfort or outdoor recreation of an individual of ordinary sensitivity and habits; or
 - 3. Endangers or injures real or personal property or the conduct of business.
- d. "Person" means any individual, association, partnership or corporation, and includes any officer, employee, department, agency or instrumentality of any association, partnership or corporation, or the state or any political subdivision of the state.
- e. "Property Boundary" means an imaginary line along the ground surface and its vertical extension, which separates the real property owned by one person from that owned by another person, but not including intrabuilding real property divisions.
- h. "Residential Property" means any parcel of ground occupied as a single or multi-family residence and either is located in a platted residential subdivision, planned unit development, minor residential development or in the R, R-1, R-2, E, E-1, M or M-1 zoning districts.

Section 4. Noise Disturbance Prohibited:

No person shall permit, make, cause to be made or continue any noise disturbance, nor shall any person or individual make any unreasonable noise in excess of the levels provided in Section 5 and measured as provided in Section 6 below.

Section 5. Maximum Permissible Noise Levels:

A noise measured or registered in the manner provided in Section 6 below from any source at a level which is in excess of the db(A) established for the time period and land uses listed in this section is hereby declared to be excessive and unusually loud and is unlawful.

In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in this section may be increased by ten db(A) for a period not to exceed fifteen minutes in any one hour period.

	Maximum Noise dBA	
	7:00am to next 7:00pm	7:00pm to next 7:00am
Land Uses: Residential Property	55 dBA	50 dBA

Section 6. Classification and Measurement of Noise:

For the purposes of determining and classifying any noise as excessive or unusually loud and, as such, in violation of Section 5 above, the following test measurements and requirements shall be applied; provided, however, that a violation of Section 4 above may occur without the following measurements being made:

- a. Noise occurring within Larimer County shall be measured at a distance of at least 25 feet from a noise source located within the public right-of-way, and if the noise source is located on private property or public property other than the public right-of-way, the noise shall be measured at or within the property boundary of the residential property where the measurement is taken.
- b. The noise shall be measured on a weighing scale on a sound level meter of standard design and quality and in accordance with the standards promulgated with the American National Standards Institute.
- c. For the purposes of this Ordinance, measurements with sound level meters shall be made when a wind velocity at the time and place of such measurement is not more than five (5) miles per hour or twenty-five (25) miles per hour with a windscreen appropriately attached to the microphone.
- d. For the purposes of this Ordinance, a noise not in violation of the parameters specified in Section 5 constitutes a noise disturbance in violation of Section 4 when, in the reasonable discretion of Larimer County Sheriff's officers, public health officials or zoning administrators, the noise constitutes an unreasonable interference with enjoyment of life, quiet, comfort or outdoor recreation of an individual or individuals of ordinary sensitivity or habits [who are] present at the time the noise is made.