Appendix U

Noise and Vibration Impact Analysis

Appendix U
Noise and Vibration Impact Analysis

This appendix describes basic noise and vibration concepts and the methods used to assess the potential construction and vehicle noise impacts. Attachment 1 presents the results of the construction noise impact analysis. Attachment 2 includes the vibration impact analysis. Traffic noise modeling inputs and outputs are presented in Attachment 3.

U.1 Noise Concepts

Sound is mechanical energy characterized by the rate of oscillation of sound waves (frequency), the speed of propagation, and the pressure level (amplitude). The human ear perceives sound as pressure on the ear. The sound pressure level is the logarithmic ratio of that perceived pressure to a reference pressure, and is expressed in decibels (dB). Approximately zero dB corresponds to the threshold of human hearing.

Environmental sounds are measured with the A-weighted scale of a sound level meter. The A scale simulates the frequency response of the human ear by giving more weight to the middle frequency sounds and less to the low and high frequency sounds. A-weighted sound levels are designated as dBA. Figure U-1 shows the sound levels (dBA) of and human response to common indoor and outdoor noise sources.

Because sounds in the environment usually vary with time, they cannot simply be described with a single number. The equivalent noise level (L_{eq}) is the constant sound level that, in a given period, has the same sound energy level as the actual time-varying sound pressure level. L_{eq} allows noise from various sources to be combined into a measure of cumulative noise exposure. It is commonly used by regulatory agencies to evaluate noise impacts.

In addition to evaluating noise impacts based on compliance with noise standards, project noise impacts can also be assessed by annoyance criteria, or the incremental increase in the existing noise level. The impact of increasing or decreasing noise levels is presented in Table U-1. For example, it shows that a change of 3 dBA is barely perceptible and that a 10 dBA increase or decrease would be perceived by someone to be a doubling or halving of the loudness.

Sound Source	Noise Level	Response	Hearing Effects	Conversational Relationships
	150		Contribution to Hearing Impairment Begins	
Carrier Deck Jet Operation	140	Painfully Loud		
	130			
		Limit Amplified Speech		
Jet Takeoff (200 ft)	120			
Auto Horn		Maximum Vocal Effort		
Riveting Machine Jet Takeoff (2000 ft)	110			
Garbage Truck				Shouting in Ear
	100			
NY Subway Station		Very Annoying		Shouting (2 ft)
Heavy Truck (50 ft)		Hearing Damage (8 hours)		
	90			
Pneumatic Drill (50 ft)		Annoying		Very Loud Conversation (4 ft)
Alarm Clock				
	80			
Freight Train (50 ft)				Loud Conversation (2 ft)
Freeway Traffic (50 ft)	70	Telephone Use Difficult		
Air Conditioning Unit (20 ft)	60	Intrusive		Loud Conversation (4 ft)
Light Auto Traffic (100 ft)	50	Quiet		Normal Conversation (12 ft)
Living Room Bedroom	40			
Library Soft Whisper (15 ft)	30	Very Quiet		
Broadcasting Studio	20			
		Just Audible		
	10			
	0	Threshold of Hearing		

Source: Siskiyou County, 1978.

Figure U-1. Sound Levels and Human Response.

Table U-1. Decibel Changes, Loudness, and Energy Loss

Sound Level Change (dBA)	Relative Loudness	Acoustical Energy Loss (%)
0	Reference	0
-3	Barely Perceptible Change	50
-5	Readily Perceptible Change	67
-10	Half as Loud	90
-20	1/4 as Loud	99
-30	1/8 as Loud	99.9

Source: FHWA, 2011

The following general guideline was used to assess daily onsite construction noise impacts, as compared to existing ambient levels:

- A less than 3 dBA increase in sound level is considered no impact;
- A 3 to 5 dBA increase in sound level is considered a slight impact;
- A 6 to 10 dBA increase in sound level is considered a moderate impact; and
- A greater than 10 dBA increase in sound level is considered a severe impact.

This analysis assumed that an increase greater than 10 dBA would be significant and would require evaluating construction noise mitigation measures.

U.2 Vibration Concepts

Vibration is caused by oscillatory waves that propagate through the ground. Ground-borne vibration can cause building floors to shake, windows to rattle, hanging pictures to fall off walls, and in some cases damage buildings.

Like noise, vibration from a single source may consist of a range of frequencies. The magnitude of vibration is commonly expressed as the peak particle velocity (PPV) in the unit of inches per second (in/sec). The PPV is the maximum velocity experienced by any point in a structure during a vibration event and indicates the magnitude of energy transmitted through vibration. PPV is an indicator often used in determining potential damage to buildings from vibration associated with blasting and other construction activities.

Table U-2 summarizes the levels of vibration from construction equipment and the typical effects on people and buildings based on a review of published vibration levels and effects (Caltrans 2004). Although blasting is considered a transient source, human response may vary widely depending on the event duration, frequency of occurrence, startle factor, level of personal activity at the time of the event, health of the individual, time of day, orientation of the individual (standing up or lying down), and political and economic perception of the blasting operation. Ground vibration as low as 0.1 in/sec due to a blasting operation may be considered distinctly to strongly perceptible by a person.

Table U-2. Summary of Construction Equipment Vibration Levels and Effects on Humans and Buildings

Effects	Peak Particle Velocity (in/sec)	
	Transient Sources [1]	Continuous/Frequent Intermittent Sources [2]
Potentially Damaged Structure Type		
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5
Human Response		
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.9	0.10
Severe	2.0	0.4

Source: Caltrans, 2004.

Notes:

[1] Transient sources create a single isolated vibration event, such as blasting and drop balls.

[2] Continuous/frequent intermittent sources include impact pile drivers, vibratory pile drivers, and vibratory compaction equipment.

Vibration from construction and traffic typically does not contribute to building damage, with the occasional exception of blasting and pile-driving during construction. U.S. Bureau of Mines (USBM) and Office of Surface Mining Reclamation and Enforcement (OSM) have developed a blast vibration limit ranging from 0.5 to 2.0 in/sec depending on vibration frequency and distances to protect buildings with various structure type and condition. Studies have shown that blast vibration typically does not damage residential structures even at levels exceeding USBM and OSM blast vibration limits (Caltrans 2004).

Average vibration amplitude is a more appropriate measure for human response as it takes time for the human body to respond. Average particle velocity over time is zero so the root-mean-square amplitude called the vibration velocity level (L_v) in VdB is used to quantify annoyance. For a person in their residence, the lower threshold for annoyance is 72 VdB. The L_v equivalent of the 0.12 in/sec damage criteria for fragile historic buildings is 90 VdB, a much higher value than what a person may perceive as “annoying.” (FTA 2006)

Vibration impacts from the project were considered significant if the peak particle velocity exceeded 0.3 in/sec based on the damage level for older residential structures. Vibration velocity level was considered significant if it exceeded the 72 VdB annoyance level.

U.3 Construction Noise Impact Assessment Method

Methods described in Federal Highway Administration's (FHWA's) Roadway Construction Noise Model (RCNM) User's Guide (2006) were used to estimate noise impacts associated with construction equipment and onsite waste hauling that are expected to be used in the action alternatives. Table U-3 presents noise levels of common construction equipment operating at full power (L_{max}) measured 50 feet from the source, the percent of time the equipment would be operated at full power (usage factor), and the equivalent noise level over a construction shift (FHWA 2006). To comply with the Siskiyou County regulation, the maximum allowable noise level in the Siskiyou County General Plan (1978) was used for equipment whose L_{max} in the Roadway Construction Noise Model exceeds the Siskiyou County regulation. The L_{eq} noise levels were calculated for each construction equipment using Equation 1.

Equation 1:

$$L_{eq_equipment} = 10 \log_{10} [10^{(Lmax_equipment/10)} \times UF_{equipment}]$$

Where:

- L_{max} is the maximum sound level for each type of equipment (dBA); and
- UF is the daily usage fraction of time that equipment is used at full power (%).

Table U-3. Construction Operations, Equipment Types, and Their Noise Levels

Equipment Types	Usage Factor	L_{max} at 50 feet (dBA)	L_{eq} at 50 feet (dBA)
Air Compressor	40%	78	74
Backhoe	40%	78	74
Blasting	1%	94	74
Compactor	20%	83	76
Concrete Mixer Truck	40%	79	75
Concrete Pump Truck[1]	20%	81	74
Crane	16%	81	73
Dozers[1]	40%	81	77
Dump Truck	40%	77	73
Excavator	40%	81	77
Front End Loader	40%	80	76
Generator	50%	81	78
Generator (< 25 kVA)	50%	73	70
Grader	40%	85	81
Jackhammer[1]	20%	81	74
Mounted Impact Hammer (hoe ram)	20%	90	83
Pickup Truck	40%	75	71
Pumps	50%	77	74
Scraper	40%	84	80
Tractor[1]	40%	81	77

Source: FHWA, 2006. Siskiyou County, 1978.

[1] Maximum allowable noise levels from construction equipment at 100 ft from Siskiyou County's General Plan converted to noise levels at 50 ft.

Noise levels were calculated for all equipment expected to be used during peak deconstruction or construction day at each dam. Detailed equipment usage for non-peak days was not available at the time of the analysis. The individual L_{eq} of each piece of equipment was combined to obtain the total L_{eq} noise level at each construction site using Equation 2.

Equation 2:

$$L_{eq_total\ source} = 10 \log_{10} [\Sigma\ 10^{(Leq_equipment/10)}]$$

Natural noise attenuation from distance between the construction sites and receptors, atmospheric absorption, and terrain were subtracted from the total L_{eq} of all equipment. The equivalent L_{eq} noise levels at each noise-sensitive receptor were calculated using the following equation:

Equation 3:

$$L_{eq_receptor} = L_{eq_total\ source} - A_{div} - A_{ground} - A_{air} - IL_{barrier}$$

Where:

- $L_{eq_total\ source}$ is the estimated total L_{eq} noise level at 50 feet (dBA) calculated using Equation 2;
- A_{div} is the geometrical divergence, or the distance attenuation (dBA) calculated using Equation 4;
- A_{ground} is the attenuation caused by interference between direct and ground-reflected sound (dBA) calculated using Equation 5;
- A_{air} is the attenuation due to atmospheric absorption (dBA); and
- $IL_{barrier}$ is the attenuation due to barrier, including natural terrain, (dBA) calculated with Equations 5 through 7.

Equation 4:

$$A_{div} = 20 \log_{10} (d/50)$$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet).

This formula results in a 6-dBA loss for each doubling of distance due to spherical divergence. The distances were measured from the construction site to the closest noise-sensitive receptor.

Ground attenuation is dependent on the ground surface characteristics, distance, and source and receptor heights. Constants in Equation 5 are based on a typical construction equipment noise frequency of 500 hertz and noise source and receptor heights (h_s and h_r)

of approximately five feet. The first term is the ground attenuation in the source zone, which extends from the source to $30h_s$ toward the receptor. The second term is the ground attenuation in the receptor zone, which extends from the receptor to $30h_r$ toward the source. The third term is the ground attenuation in the zone between the source and receptor zones. The ground factor (G) for each zone is zero if the ground surface consists of asphalt or concrete pavement, water, or any hard ground with low porosity. The ground factor for soft ground, or porous ground that is covered by vegetation or loose materials such as snow and pine needles, is zero. For zones with a mixture of soft and hard ground surface areas, the ground factor is the fraction of the ground that is soft.

Equation 5:

$$A_{ground} = (6.5G_s - 1.5) + (6.5G_r - 1.5) - 3\{1-[30(h_s + h_r)/d]\}(1-G_m)$$

Where:

- G_s is the ground factor for the source zone (source to $30h_s$ toward the receptor);
- G_r is the ground factor for the receptor zone (receptor to $30h_r$ toward the source);
- h_s is the source height (ft);
- h_r is the receptor height (ft);
- d is the distance between the source and the receptor; and
- G_m is the ground factor for the middle zone (between source and receptor zones).

Terrain attenuation was calculated using the Equations 6 through 8. A_{ground} in Equation 8 cancels out the term in Equation 3.

Equations 6 through 8:

$$N = (2 / \lambda)(d_1 + d_2 - d)$$

$$K = \exp\{-0.0005 \sqrt{[(d_1 d_2 d) / (N\lambda)]}\}$$

$$IL_{barrier} = 10 \log_{10}(3 + 10NK) - A_{ground}$$

Where:

- λ is the wavelength of the sound wave (ft);
- d_1 is the distance between the top of the hill and the noise source (ft);
- d_2 is the distance between the top of the hill and the noise receptor (ft);
- d is the distance between the source and the receptor (ft);
- N is called the Fresnel number;
- K is the atmospheric correction factor for d > 100 m; and
- A_{ground} is the ground attenuation, which eliminates the A_{ground} term in Equation 3.

Attenuation associated with atmospheric absorption is dependent on temperature, relative humidity, and frequency of the sound waves. It should be noted that as humidity decreases, the atmospheric attenuation increases because dry air is a poor conductor of sound compared to humid air. Based on an average air temperature of 50°F and 50 percent humidity sound attenuates at 1.9 dB per kilometer (0.0006 dB per ft) at 500 Hz (Harris 1998).

The construction noise level calculated with the above equations must be added to the existing noise levels at the receptor to determine the noise level at the receptor resulting from construction activities. The basic concept of Equation 2 was used to add construction noise impact to existing noise levels at the receptor, as shown in Equation 8. Average daytime L_{eq} and nighttime L_{eq} noise levels for rural residential areas found in the *U.S. EPA Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety* (1974) were used to estimate ambient noise levels at selected receptor locations. These levels are 40 dBA during the day (7 am to 10 pm) and 30 dBA at night (10 pm to 7am). Nighttime existing level is used at Iron Gate Dam and Copco 1 Dam receptors, where there is possible impact from nighttime construction activities.

Equation 8:

$$L_{eq_receptor} = 10 \log_{10} [10^{(Leq_total\ equipment/10)} + 10^{(Leq_existing/10)}]$$

Where:

- $L_{eq_total\ equipment}$ is the equivalent total L_{eq} noise level at the receptor due to construction activities after distance, terrain, and atmospheric attenuation are taken (dBA); and
- $L_{eq_existing}$ is 40 dBA for daytime noise analysis and 30 dBA for nighttime noise analysis (dBA).

The existing L_{eq} was subtracted from the resulting total L_{eq} at the receptor to calculate the increase in noise levels due to construction activity. This impact was compared against the criteria of 10 dBA to determine significance.

Attachment 1 presents the results of the construction noise impact analysis.

U.4 Construction Vibration Impact Assessment Method

Vibration from construction projects is caused by general equipment operations, and is usually highest during pile driving, soil compacting, jack hammering, demolition, and blasting activities. Although it is conceivable for ground-borne vibration from construction projects to cause building damage, the vibration from construction activities is almost never of sufficient amplitude to cause even minor cosmetic damage to buildings. The primary concern is that the vibration can be intrusive and annoying to

people inside buildings. Table U-4 presents the vibration levels for typical construction equipment published in Federal Transit Administration's (FTA) Transit Noise and Vibration Impact Assessment (2006).

Table U-4. Vibration Levels for Construction Equipment

Equipment Types	PPV at 25 feet (in/sec)	L_v at 25 feet (VdB)
Clam Shovel Drop	0.202	94
Vibratory Roller	0.210	94
Large Bulldozer / Hoe Ram	0.089	87
Caisson Drilling	0.089	87
Loaded Trucks	0.076	86
Jackhammer	0.035	79

Source: FTA, 2006.

Total PPV at each construction site is the sum of PPV for all equipment at the construction site. Equation 9 was used to calculate the construction equipment vibration levels at the receiver, based on a reference vibration at a distance of 25 feet.

Equation 9:

$$PPV_{receptor} = PPV_{source} (25/d)^{1.5}$$

Where:

- PPV_{source} is the total vibration level at 25 feet (in/sec); and
- d is the distance from the equipment to the receptor (ft).

Vibration levels expressed as VdB are treated similarly to noise levels. Equation 10 was used to calculate the total L_v from all construction equipment. The equivalent L_v at the receptor was calculated using Equation 11.

Equation 10:

$$L_{v_total} = 20 \log_{10} \Sigma\, 10^{(Lv_equipment/20)}$$

Equation 11:

$$L_{v_receptor} = L_{v_source} - 30 \log_{10} (d/25)$$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet).

Vibration levels associated with blasting are site-specific and are dependent on the amount of explosive used, soil conditions between the blast site and the receptor, and the elevation where blasting would take place (specifically, the below surface elevation where bedrock would be encountered). Blasting below the surface would produce lower vibration levels at a receptor due to additional attenuation provided by distance and transmission through soil and rock. Vibration from blasting was estimated using the Blast Vibration Prediction Curves published by L.L. Oriard in 1999 and 2000 (Caltrans 2004). One can estimate the PPV of blasting based on the square root scaled distance (Equation 12). The estimated PPV was converted to L_v using Equation 13. Actual blasting procedures would be dictated by site-specific conditions as determined by the construction contractor prior to construction and through monitoring during construction.

Equation 12:

$$D_s = d / \sqrt[3]{W}$$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet); and
- W is the charge weight (pounds).

Equation 13:

$$L_v = 20 \text{ Log}_{10}(PPV/10^6) - 12 \text{ (assuming a crest factor of 4)}$$

Calculated PPV and L_v were compared against the criteria of 0.3 in/sec and 72 VdB, respectively, to determine significance.

U.5 Construction-Related Traffic Noise Impact Assessment Methodology

Peak hour traffic noise levels for the Existing, No-Action, and Action Alternatives were estimated for construction workers' commuting vehicles, delivery trucks, and trucks hauling waste materials using the FHWA Traffic Noise Model, Version 2.5 (TNM2.5). TNM2.5 is capable of modeling noise impacts from automobiles, medium trucks (2 axles), heavy trucks (3 or more axles), buses, and motorcycles factoring in vehicle volume, vehicle speed, roadway configuration, distance to the noise-sensitive receptors, atmospheric absorption, and ground attenuation characteristics (FHWA, 1998a and 2004a). The model is based on measurements collected by the Volpe National Transportation Systems Center Acoustics Facility and is generally considered to be accurate within +/- 3 dB (FHWA, 1998b).

To simplify the analysis, bus and motorcycle volumes were assumed to be negligible and attenuation from the natural terrain and vegetation were not included. It was assumed that

there would be equal volumes of traffic on each direction of a roadway and peak hour traffic coincides with the worst 1-hour L_{eq}. Peak hour noise levels were modeled for generic receptors 50 and 500 feet from the edge of the road. Fifty feet represents the minimum possible distance for a receptor along any roadway, and 500 feet is the maximum recommended receptor distance for traffic noise models (Caltrans, 2006). The modeled roadway segment should be longer than eight times the maximum source to receptor distance (FHWA 2004b). The maximum distance between the source and receptor is 500 feet; therefore an approximately 5,000 ft road segment was modeled.

Average daily traffic (ADT) counts published by ODOT (2010) and Caltrans (2010) provided the basis for estimating the existing noise levels on OR 66, US 97, and I-5. Existing 1-hr L_{eq} for Topsy Grade Road and Copco Road and vehicle distributions were provided by the transportation engineers (J. Key, personal communication, December 13, 2010). Based on a review of published ODOT and Caltrans traffic counts, peak hour traffic (PHT) volume was typically 10 to 20 percent of the average daily traffic volume. Changes in noise levels would be greater when the baseline traffic counts are lower; therefore for a conservative analysis, the analysis assumed that PHT is 10 percent of ADT. As free-flow speeds were not available, posted speed limits were entered in the model to be conservative. Because measured traffic counts on I-5 between the City of Yreka and Anderson, California, are generally higher than those north of the City of Yreka, significance for the Yreka-Anderson segment was based on the significance of the segment north of the City of Yreka, California. Traffic counts and characteristics of Topsy Grade Road was used to model noise levels on Ager-Beswick Road. It was assumed that there would be no increase in regional traffic between Existing Conditions and No-Action Alternative.

Under the Proposed Action, trucks would haul recyclable metal waste to Weed, California for waste originating in California and to Klamath Falls, Oregon for waste originating in Oregon. Wood waste from Copco 2 Dam would likely be hauled to a hazardous waste landfill in Anderson, CA. For construction of fish passages, rebar and wood would be supplied from Medford, OR, and concrete would be transported from the City of Yreka, CA. The haul routes would likely be I-5, US 97, OR 66, Copco Road, Topsy Grade Road, and Ager-Beswick Road. Details regarding the roadways affected by this Proposed Action are presented in the Transportation Section (Section 3.22, Traffic and Transportation). The greater of the number of trucks available for each material or the peak daily haul truck volumes divided by 8 was used as the hourly truck volume. The estimated shift length is 8 hours. The hourly truck volumes were added to the existing/no-action peak hour traffic volumes. This analysis assumes that off-site hauling to suppliers and disposal areas would only occur during the daytime. All new truck trips are assumed to consist of heavy trucks, those with 3 axles or greater for use in the TNM2.5 model.

Construction workers would commute from the City of Yreka, California, or Medford, Oregon, to Iron Gate, Copco 1, and Copco 2 sites and from Keno or Klamath Falls, Oregon to the J.C. Boyle site according to the Population and Housing Section (Section 3.17, Population and Housing). Maximum number of construction workers for

J.C. Boyle was added to automobile traffic on US 97, OR 66, and Topsy Grade Road. Maximum total construction workers for Iron Gate, Copco 1, and Copco 2 were added to automobile traffic volume on Copco Rd and I-5. Because the distribution of workers from Medford, Oregon, and the City of Yreka, California, on I-5 are unknown, maximum number of workers commuting to the California dams were added to both segments of I-5 for a conservative analysis.

For Alternatives 2, 3, and 5, truck and commute trips for all dams using the same road were combined. For Alternative 4, the maximum number of trucks and passenger vehicles traveling each road was used because construction is scheduled to occur one dam at a time.

Significance is defined as an increase of 12 dBA in California (Caltrans 2006) or 10 dBA in Oregon (ODOT 2009) or more above existing 1-hour Leq for traffic-induced noise.

The results of the traffic noise modeling analysis are presented in Attachment 3.

U.6 References

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Attachment 1

Construction Noise Impact Analysis

Table U1A. Copco 1 Dam and Powerhouse - Peak Day Construction Equipment Noise Level

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 1

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	2	76
Excavator	77	4	83
Hoe ram	83	1	83
Articulated wheel loader	75	2	78
Dump truck	73	2	76
Pick-up truck	71	4	77
Water tanker, off-highway	77	1	77
Engine generator	78	2	81
Air compressor	74	4	80
Drill	74	4	80
Submersible pump	78	2	81
Blast	74	9	84
		TOTAL	91

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 2

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	2	76
Excavator	77	1	77
Pick-up truck	71	4	77
Water tanker, off-highway	77	1	77
Engine generator	78	2	81
Air compressor	74	4	80
Drill	74	4	80
Submersible pump	78	2	81
		TOTAL	88

Fish Passage at Four Dams

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	4	79
Excavator	77	1	77
Hoe ram	83	1	83
Articulated wheel loader	75	1	75
Dump truck	73	1	73
Crawler dozer	77	1	77
Pick-up truck	71	3	76
Water tanker, off-highway	77	1	77
Concrete mixer	75	6	83
Concrete pump truck	74	1	74
Compactor	76	1	76
Engine generator	78	1	78
Portable generator	70	2	73
Air compressor	74	2	77
Drill	74	1	74
Submersible pump	78	2	81
		TOTAL	90

Calculations based on FHWA Roadway Construction Noise Model.

Table U1B. Attenuation Calculations for Copco 1 Receptor

Receptor Name	Residence on Janice Ave	
Distance from Source to Receptor	2200 ft	
Total Attenuation for Receptor	39 dB	$A_{total} = A_{div} + A_{air} + A_{ground} + IL_{topography}$

Distance Attenuation

Divergence (A_{div}, dB)	33	$A_{div} = 20 \times \log(d/50)$

Atmospheric Attenuation

Assumptions		
Ambient pressure (kPa)	101.3	
Average temperature (F)	50	
Relative humidity (%)	50	
Frequency of noise source (Hz)	500	
Air Attenuation Coefficient (α, dB/km)	1.9	
(dB/ft)	0.0006	
Atmospheric Attenuation (A_{air}, dB)	1.3	$A_{air} = \alpha d$

Conversion:	0.3048	m/ft
	1000	m/km

Weather in Montague, CA

Average temperature	51
Average relative humidity	60%

Ground Attenuation

Parameters		
Source Height (hs, ft)	5	
Receptor Height (hr, ft)	5	
ds	150	ds = 30 x hs
dm	1,900	between ds and dr
dr	150	dr = 30 x hr
Ground Factor at Source (Gs)	0	Ground type G
Ground Factor at Receptor (Gr)	0	Hard 0
Ground Factor in the Middle (Gm)	0.4	Soft 1
As	-1.5	As = (6.5 x G) - 1.5
Ar	-1.5	Ar = (6.5 x G) - 1.5
Am	-1.6	
Ground Attenuation (A_{ground}, dB)	0.0	A_{ground} = As + Ar + Am

Assume 500 Hz.

Terrain Attenuation

Parameters		
Distance from source to apex of hill (d1, ft)	502	
Distance from receptor to apex of hill (d2, ft)	1700	
Distance from source to receptor (d, ft)	2,200	
Speed of Sound (ft/sec)	1126	
Frequency (Hz)	500	
Wavelength (λ)	2.25	
Fresnel Number (N)	2.4	N = (2 / λ) x [d1 + d2 - d]
Atmospheric Correction (K)	0.00	K = exp[-0.0005 √[(d1 x d2 x d) / (N x λ)]]
Topographic Attenuation (dB)	5	IL = 10 x log[3 + 10 x N x K] - A_{ground}

Reference:

Harris, Cyril M. 1998. Handbook of Acoustical Measurements and Noise Control. 3rd ed. - Chapter 3 Calculation of Attenuation

Weather in Montague, CA. http://qwikcast.weatherbase.com/weather/weatherall.php3?s=88057&refer

Table U1C. Receptor Noise Level from Construction Activities at the Copco 1 Dam and Powerhouse

Alternative	Project 1-hr Leq at Receptor (dBA)	Above Existing (dBA)
Proposed Action	49-52	10-22
Partial Removal	49-52	10-22
Fish Passage at 4 Dams	52	12
Fish Passage at 2 Dams	49-52	10-22
Criteria	N/A	10

Proposed Alternative; Partial Removal Alternative; Fish Passage at Two Dams, Remove Two Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	91	52	22
7:00	40	91	52	12
8:00	40	91	52	12
9:00	40	91	52	12
10:00	40	91	52	12
11:00	40	0	40	0
12:00	40	91	52	12
13:00	40	91	52	12
14:00	40	91	52	12
15:00	40	88	50	10
16:00	40	88	50	10
17:00	40	88	50	10
18:00	40	0	40	0
19:00	40	88	50	10
20:00	40	88	50	10
21:00	40	88	50	10
22:00	30	88	49	19
23:00	30	88	49	19

Assume one-hour breaks for construction workers at 11:00 and 18:00.

Fish Passage at Four Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	0	30	0
7:00	40	90	52	12
8:00	40	90	52	12
9:00	40	90	52	12
10:00	40	90	52	12
11:00	40	0	40	0
12:00	40	90	52	12
13:00	40	90	52	12
14:00	40	90	52	12
15:00	40	90	52	12
16:00	40	0	40	0
17:00	40	0	40	0
18:00	40	0	40	0
19:00	40	0	40	0
20:00	40	0	40	0
21:00	40	0	40	0
22:00	30	0	30	0
23:00	30	0	30	0

Assume a one-hour break for construction workers at 11:00.

Table U1D. Iron Gate Dam and Powerhouse - Peak Day Construction Equipment Noise Level

Proposed Action; Partial Facilities Removal; Remove Two Dams (per shift)

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	2	76
Excavator	77	4	83
Dump truck	73	20	86
Crawler dozer	77	2	80
Pick-up truck	71	3	76
Water tanker, off-highway	77	1	77
Engine generator	78	2	81
Submersible pump	78	4	84
		TOTAL	91

Fish Passage at Four Dams

Equipment Type	Leq at 50 ft per Unit (dBA)	Number of Equipment	Total Leq at 50 ft per Equipment Type (dBA)
Crane	73	4	79
Excavator	77	1	77
Hoe ram	83	1	83
Articulated wheel loader	75	1	75
Dump truck	73	2	76
Crawler dozer	77	1	77
Pick-up truck	71	3	76
Water tanker, off-highway	77	1	77
Concrete mixer	75	4	81
Concrete pump truck	74	1	74
Compactor	76	1	76
Engine generator	78	3	82
Portable generator	70	2	73
Air compressor	74	2	77
Drill	74	2	77
Submersible pump	78	2	81
		TOTAL	91

Calculations based on FHWA, Roadway Construction Noise Model, January 2006.

Table U1E. Attenuation Calculations for Iron Gate Receptor

Receptor Name	Residence on Tarpon Drive	
Distance from Source to Receptor	4500 ft	
Total Attenuation for Receptor	46 dB	$A_{total} = A_{div} + A_{air} + A_{ground} + IL_{topography}$

Distance Attenuation

Divergence (A_{div}, dB)	39	$A_{div} = 20 \times \log(d/50)$

Atmospheric Attenuation

Assumptions		
Ambient pressure (kPa)	101.3	
Average temperature (F)	50	
Relative humidity (%)	50	
Frequency of noise source (Hz)	500	
Air Attenuation Coefficient (α, dB/km)	1.9	
(dB/ft)	0.0006	
Atmospheric Attenuation (A_{air}, dB)	2.6	$A_{air} = \alpha d$

Conversion:	0.3048	m/ft
	1000	m/km

Weather in Montague, CA

Average temperature	51
Average relative humidity	60%

Ground Attenuation

Parameters		
Source Height (hs, ft)	5	
Receptor Height (hr, ft)	5	
ds	150	ds = 30 x hs
dm	4,201	between ds and dr
dr	150	dr = 30 x hr
Ground Factor at Source (Gs)	0	
Ground Factor at Receptor (Gr)	1	
Ground Factor in the Middle (Gm)	0.4	
As	-1.5	As = (6.5 x G) - 1.5
Ar	5	Ar = (6.5 x G) - 1.5
Am	-1.7	
Ground Attenuation (A_{ground})	2	A_{ground} = As + Ar + Am

Ground type	G
Hard	0
Soft	1

Assume 500 Hz.

Terrain Attenuation

Parameters		
Distance from source to apex of hill (d1, ft)	1600	
Distance from receptor to apex of hill (d2, ft)	2901	
Distance from source to receptor (d, ft)	4,501	
Speed of Sound (ft/sec)	1126	
Frequency (Hz)	500	
Wavelength (λ)	2.25	
Fresnel Number (N)	0.2	N = (2 / λ) x [d1 + d2 - d]
Atmospheric Correction (K)	0.00	K = exp[-0.0005 √[(d1 x d2 x d) / (N x λ)]]
Topographic Attenuation (dB)	3	IL = 10 x log[3 + 10 x N x K] - A_{ground}

Reference:
Harris, Cyril M. 1998. Handbook of Acoustical Measurements and Noise Control. 3rd ed. - Chapter 3 Calculation of Attenuation
Weather in Montague, CA. http://qwikcast.weatherbase.com/weather/weatherall.php3?s=88057&refer

Table U1F. Receptor Noise Level from Construction Activities at the Iron Gate Dam and Powerhouse

Alternative	Project 1-hr Leq at Receptor (dBA)	Above Existing (dBA)
Proposed Action	44-46	6-14
Partial Removal	44-46	6-14
Fish Passage at 4 Dams	46	6
Fish Passage at 2 Dams	44-46	6-14
Criteria	N/A	10

Proposed Alternative; Partial Removal Alternative; Fish Passage at Two Dams, Remove Two Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	0	30	0
7:00	40	91	46	6
8:00	40	91	46	6
9:00	40	91	46	6
10:00	40	91	46	6
11:00	40	0	40	0
12:00	40	91	46	6
13:00	40	91	46	6
14:00	40	91	46	6
15:00	40	91	46	6
16:00	40	91	46	6
17:00	40	91	46	6
18:00	40	91	46	6
19:00	40	0	40	0
20:00	40	91	46	6
21:00	40	91	46	6
22:00	30	91	44	14
23:00	30	0	30	0

Assume one-hour breaks for construction workers at 11:00 and 19:00.

Fish Passage at Four Dams Alternative

Time	Existing Leq (dBA)	Source Leq (dBA)	Receptor Leq (dBA)	Receptor Leq Above Existing (dBA)
0:00	30	0	30	0
1:00	30	0	30	0
2:00	30	0	30	0
3:00	30	0	30	0
4:00	30	0	30	0
5:00	30	0	30	0
6:00	30	0	30	0
7:00	40	91	46	6
8:00	40	91	46	6
9:00	40	91	46	6
10:00	40	91	46	6
11:00	40	0	40	0
12:00	40	91	46	6
13:00	40	91	46	6
14:00	40	91	46	6
15:00	40	91	46	6
16:00	40	0	40	0
17:00	40	0	40	0
18:00	40	0	40	0
19:00	40	0	40	0
20:00	40	0	40	0
21:00	40	0	40	0
22:00	30	0	30	0
23:00	30	0	30	0

Assume a one-hour break for construction workers at 11:00.

Attachment 2

Construction Vibration Impact Analysis

Table U2A. Copco 1 Dam and Powerhouse - Peak Day Construction Equipment Vibration Level

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 1

		At Source 25 ft		At Receptor 2200 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	2	0.404	100	0.0005	42
Excavator	4	0.356	99	0.0004	41
Hoe ram	1	0.089	87	0.0001	29
Articulated wheel loader	2	0.178	93	0.0002	35
Dump truck	2	0.152	92	0.0002	34
Pick-up truck	4	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0001	28
Engine generator	2	0	0	0.0000	0
Air compressor	4	0	0	0.0000	0
Drill	4	0.14	91	0.0002	33
Submersible pump	2	0	0	0.0000	0
TOTAL without blasting	N/A	1.40	111	0.002	53
Blast	9	N/A	N/A	0.0630	84
TOTAL with blasting	N/A	N/A	N/A	0.065	84

Proposed Action; Partial Facilities Removal; Remove Two Dams - Shift 1

		At Source 25 ft		At Receptor 2200 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	2	0.404	100	0.0005	42
Excavator	1	0.089	87	0.0001	29
Pick-up truck	4	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0001	28
Engine generator	2	0	0	0.0000	0
Air compressor	4	0	0	0.0000	0
Drill	4	0.14	91	0.0002	33
Submersible pump	2	0	0	0.0000	0
TOTAL		0.71	105	0.001	47

Fish Passage at Four Dams

		At Source 25 ft		At Receptor 2200 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	4	0.808	106	0.0010	48
Excavator	1	0.089	87	0.0001	29
Hoe ram	1	0.089	87	0.0001	29
Articulated wheel loader	1	0.089	87	0.0001	29
Dump truck	1	0.076	86	0.0001	28
Crawler dozer	1	0.089	87	0.0001	29
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0001	28
Concrete mixer	6	0.456	102	0.0006	44
Concrete pump truck	1	0.076	86	0.0001	28
Compactor	1	0.21	94	0.0003	36
Engine generator	1	0	0	0.0000	0
Portable generator	2	0	0	0.0000	0
Air compressor	2	0	0	0.0000	0
Drill	1	0.035	79	0.0000	21
Submersible pump	2	0	0	0.0000	0
TOTAL		2.09	115	0.0025	57

Calculations based on FTA Transit Noise and Vibration Impact Assessment (2006).

Table U2B. Copco 2 Dam - Peak Day Construction Equipment Vibration Level

Proposed Action

		At Source 25 ft		At Receptor 3700 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	3	0.606	104	0.0003	39
Excavator	2	0.178	93	0.0001	28
Hoe ram	2	0.178	93	0.0001	28
Articulated wheel loader	3	0.267	97	0.0001	32
Dump truck	2	0.152	92	0.0001	27
Crawler dozer	1	0.089	87	0.0000	22
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	21
Engine generator	5	0	0	0.0000	0
Air compressor	3	0	0	0.0000	0
Drill	4	0.14	91	0.0001	26
Submersible pump	5	0	0	0.0000	0
TOTAL		1.69	113	0.0009	48

Partial Removal

		At Source 25 ft		At Receptor 3700 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	3	0.606	104	0.0003	39
Excavator	2	0.178	93	0.0001	28
Hoe ram	2	0.178	93	0.0001	28
Articulated wheel loader	3	0.267	97	0.0001	32
Dump truck	2	0.152	92	0.0001	27
Crawler dozer	1	0.089	87	0.0000	22
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	21
Engine generator	5	0	0	0.0000	0
Air compressor	3	0	0	0.0000	0
Drill	3	0.105	89	0.0001	24
Submersible pump	5	0	0	0.0000	0
TOTAL		1.65	113	0.0009	48

Fish Passage at Four Dams; Fish Passage at Two Dams

		At Source 25 ft		At Receptor 3700 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	3	0.606	104	0.0003	39
Excavator	1	0.089	87	0.0000	22
Hoe ram	1	0.089	87	0.0000	22
Articulated wheel loader	1	0.089	87	0.0000	22
Dump truck	2	0.152	92	0.0001	27
Crawler dozer	1	0.089	87	0.0000	22
Pick-up truck	2	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	21
Concrete mixer	3	0.228	96	0.0001	31
Concrete pump truck	1	0.076	86	0.0000	21
Compactor	1	0.21	94	0.0001	29
Engine generator	1	0	0	0.0000	0
Portable generator	2	0	0	0.0000	0
Air compressor	2	0	0	0.0000	0
Drill	1	0.035	79	0.0000	14
Submersible pump	2	0	0	0.0000	0
TOTAL		1.74	113	0.0010	48

Calculations based on FTA Transit Noise and Vibration Impact Assessment (2006).

Table U2C. Iron Gate Dam and Powerhouse - Peak Day Construction Equipment Vibration Level

Proposed Action; Partial Facilities Removal; Remove Two Dams (per shift)

		At Source 25 ft		At Receptor 4500 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	2	0.404	100	0.0002	32
Excavator	4	0.356	99	0.0001	31
Dump truck	20	1.52	112	0.0006	44
Crawler dozer	2	0.178	93	0.0001	25
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	18
Engine generator	2	0	0	0.0000	0
Submersible pump	4	0	0	0.0000	0
TOTAL		2.53	116	0.0010	48

Fish Passage at Four Dams

		At Source 25 ft		At Receptor 4500 ft	
Equipment Description	**Number of Equipment**	**PPV (in/sec)**	**L_v (VdB)**	**PPV (in/sec)**	**L_v (VdB)**
Crane	4	0.808	106	0.0003	38
Excavator	1	0.089	87	0.0000	19
Hoe ram	1	0.089	87	0.0000	19
Articulated wheel loader	1	0.089	87	0.0000	19
Dump truck	2	0.152	92	0.0001	24
Crawler dozer	1	0.089	87	0.0000	19
Pick-up truck	3	0	0	0.0000	0
Water tanker, off-highway	1	0.076	86	0.0000	18
Concrete mixer	4	0.304	98	0.0001	30
Concrete pump truck	1	0.076	86	0.0000	18
Compactor	1	0.21	94	0.0001	26
Engine generator	1	0	0	0.0000	0
Portable generator	2	0	0	0.0000	0
Air compressor	2	0	0	0.0000	0
Drill	2	0.07	85	0.0000	17
Submersible pump	2	0	0	0.0000	0
TOTAL		2.05	114	0.0008	46

Calculations based on FTA Transit Noise and Vibration Impact Assessment (2006).

Table U2D. Summary of Vibration Levels from Construction Equipment

	Total Equipment Peak Particle Velocity (in/sec) for each Alternative				
Source Location	**Full Removal Alternative**	**Partial Removal Alternative**	**Fish Passage at Four Dams**	**Fish Passage at Two Dams**	**Significance Criteria**
Copco1	0.063	0.063	0.003	0.063	0.3
Copco 2	0.001	0.001	0.001	0.001	0.3
Iron Gate	0.001	0.001	0.001	0.001	0.3

	Total Equipment Ground-Vibration (VdB) for Each Alternative				
Source Location	**Full Removal Alternative**	**Partial Removal Alternative**	**Fish Passage at Four Dams**	**Fish Passage at Two Dams**	**Significance Criteria**
Copco1	84	84	53	84	72
Copco 2	44	44	46	46	72
Iron Gate	40	40	43	40	72

Attachment 3

Traffic Noise Impact Analysis

Table U3A. Estimated Traffic Counts for Existing Conditions

Road Segment	AADT	AADT Distribution (%) [1]			AADT Distribution			PHT Distribution [3]			PHT Distribution for Each Direction [4]		
		Auto [2]	Medium Trucks [2]	Heavy Trucks [2]	Auto	Medium Trucks	Heavy Trucks	Auto	Medium Trucks	Heavy Trucks	Auto	Medium Trucks	Heavy Trucks
Topsy Grade Rd [5]	200	58.82	34.85	6.33	118	70	13	12	7	2	6	4	1
OR 66 [6]	500	58.82	34.85	6.33	294	174	32	29	17	3	15	9	2
US 97 [7]	6300	33.55	28.34	38.11	2114	1785	2401	211	179	240	106	90	120
Ager-Beswick Rd [8]	200	58.82	34.85	6.33	117.64	69.7	12.66	12	7	2	6	4	1
Copco Rd [5]	250	71.34	0	28.66	178	0	72	18	0	7	9	0	4
I-5 (Oregon) [9]	24400	69.45	17.56	12.99	16946	4285	3170	1695	428	317	848	214	159
I-5 (California) [10]	15200	71.34	0	28.66	10844	0	4356	1084	0	436	542	0	218

Notes:

[1] AADT distribution percentage provided by transportation engineers (J. Key, personal communication, December 13, 2010).

[2] TNM vehicle classification: Auto = cars and light duty trucks, Medium Trucks = cargo vehicles with two axles and six tires; Heavy trucks - cargo vehicles with three or more axles.

[3] PHT assumed to be 10% of AADT based on a review of published Caltrans and ODOT traffic counts (ODOT, 2010; Caltrans, 2010).

[4] PHT for each direction assumed to be the same in both direction of traffic.

[5] Traffic count estimated from field observations (CDM, field observations, October 17, 2010).

[6] AADT at MP 48.73, 0.02 mile east of Hamaker Mountain Road (ODOT, 2010).

[7] AADT at MP 273.92, 0.30 mile south of Nevada Avenue Interchange (ODOT, 2010).

[8] Assume Ager-Beswick Rd is similar to Topsy Grade Rd (J. Key, personal communication, February 8, 2011).

[9] AADT at MP18.60, 0.50 mile south of North Ashland Interchange (ODOT, 2010).

[10] Lowest AADT measured along I-5 in 2009 between Copco Rd and Oberlin Rd; MP 61.553 at Henley Way (Caltrans, 2010).

Table U3B. Characteristics of Roads Analyzed for Hauling and Worker Commute Noise Impact

Road Segment	Total Number of Lanes	Width (feet)			Modeled Speed
		North/Eastbound Lanes	Median	SB/WB	
Topsy Grade Road	2	12	0	12	35
US 97	2	12	0	12	65
I-5 (Oregon)	4	25	100	25	65
OR 66	2	12	0	12	55
I-5 (California)	4	25	70	25	70
Copco Road	2	12	0	12	55
Ager-Beswick Road	2	12	0	12	35

Source: J. Key, personal communication, December 29, 2010 and February 8, 2011

Table U3C. Maximum Estimated Number of Construction Workers

	Number of Workers			
Dam	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
J.C. Boyle	45	41	20	20
Copco 1 (day)	36	36	25	36
Copco 1 (night)	20	20	N/A	20
Copco 2	40	38	20	20
Iron Gate (day)	40	40	30	40
Iron Gate (night)	40	40	N/A	40
CA Dams Subtotal (day)	116	114	75	96
CA Dams Subtotal (night)	60	60	0	60

Alternative 4

Road Segment	Direction	JC Boyle	Copco 1	Copco 2	Iron Gate	Maximum
Topsy Grade Rd	North	0	0	0	0	0
	South	20	0	0	0	20
OR 66	East	0	0	0	0	0
	West	20	0	0	0	20
US 97	North	0	0	0	0	0
	South	20	0	0	0	20
Ager Rd	North	0	0	0	0	0
	South	0	0	0	0	0
Copco Rd	East	0	25	20	30	30
	West	0	0	0	0	0
I-5 (Oregon)	North	0	0	0	0	0
	South	0	25	20	30	30
I-5 (California)	North	0	25	20	30	30
	South	0	0	0	0	0

		Number of Commuters per Hour			
Road Segment	**Direction**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**
Topsy Grade Rd	North	0	0	0	0
	South	45	41	20	20
OR 66	East	0	0	0	0
	West	45	41	20	20
US 97	North	0	0	0	0
	South	45	41	20	20
Ager Rd	North	0	0	0	0
	South	0	0	0	0
Copco Rd	East	116	114	30	96
	West	0	0	0	0
I-5 (Oregon)	North	0	0	0	0
	South	116	114	30	96
I-5 (California)	North	116	114	30	96
	South	0	0	0	0

Assume all construction workers arrive within an hour.

Assumption from Population and Housing Section:

- Workers for JC Boyle assumed to commute from Klamath Falls, via US 97, OR 66, and Topsy Grade Rd.
- Workers for Iron Gate & Copco facilities assumed to commute from Medford and Yreka, via I-5 and Copco Rd.

Alt 4 construction at each dam occurs in a different year, therefore, the maximum worker travel on each road is used.

Table U3D. Peak Hourly Off-Site Haul Trucks

Dam	Destination	Origin	Alt 2 Peak Daily		Alt 3 Peak Daily		Alt 4 Peak Daily		Alt 5 Peak Daily	
			Units	Trips	Units	Trips	Units	Trips	Units	Trips
J.C. Boyle	Klamath Falls		4	20	2	10	0	0	0	0
		Medford	0	0	0	0	2	2	2	2
		Yreka	0	0	0	0	2	9	2	9
Copco 1		Medford	0	0	0	0	2	2	0	0
		Yreka	0	0	0	0	2	9	0	0
	Yreka		2	10	1	5	0	0	2	10
Copco 2		Medford	0	0	0	0	2	2	2	2
		Yreka	0	0	0	0	2	9	2	9
	Yreka		5	25	3	15	0	0	0	0
	Anderson		1	2	1	2	0	0	0	0
Iron Gate		Medford	0	0	0	0	2	2	0	0
		Yreka	0	0	0	0	2	9	0	0
	Yreka		2	10	1	5	0	0	2	10

Dam	Destination	Origin	Peak Hourly Trucks				Road Segments						
			Alt 2	Alt 3	Alt 4	Alt 5	Topsy Grade	OR 66	US 97	Ager	Copco	I-5 (OR)	I-5 (CA)
J.C. Boyle	Klamath Falls		4	4	0	0	North	East	North				
		Medford	0	0	2	2	South	East				South	
		Yreka	0	0	2	2	South	East					North
Copco 1		Medford	0	0	2	0					East	South	South
		Yreka	0	0	2	0				North			
	Yreka		2	1	0	2					West		South
Copco 2		Medford	0	0	2	2					East	South	South
		Yreka	0	0	2	2				North			
	Yreka		5	3	0	0					West		South
	Anderson		1	1	0	0				South			South
Iron Gate		Medford	0	0	2	0					East	South	South
		Yreka	0	0	2	0					East		North
	Yreka		2	1	0	2					West		South

Unless the number of trips divided by the number of units is greater than 8 (construction shift length), peak daily units is used as the peak hourly trucks.
Assumed single truck makes maximum two trips to Klamath Falls from J.C. Boyle in Alt 3.

		Number of Heavy Trucks per Hour			
Road Segment	Direction	Alt 2	Alt 3	Alt 4	Alt 5
Topsy Grade Rd	North	4	4	0	0
	South	0	0	4	4
OR 66	East	4	4	4	4
	West	0	0	0	0
US 97	North	4	4	0	0
	South	0	0	0	0
Ager Rd	North	0	0	2	2
	South	1	1	0	0
Copco Rd	East	0	0	4	2
	West	9	5	0	4
I-5 (Oregon)	North	0	0	0	0
	South	0	0	2	4
I-5 (California)	North	0	0	2	2
	South	10	6	2	6

Alt 4 construction at each dam occurs in a different year, therefore, the maximum truck travel on each road is used.

Alternative 4		Number of Heavy Trucks per Hour				
Road Segment	Direction	JC Boyle	Copco 1	Copco 2	Iron Gate	Maximum
Topsy Grade Rd	North	0	0	0	0	0
	South	4	0	0	0	4
OR 66	East	4	0	0	0	4
	West	0	0	0	0	0
US 97	North	0	0	0	0	0
	South	0	0	0	0	0
Ager Rd	North	0	2	2	0	2
	South	0	0	0	0	0
Copco Rd	East	0	2	2	4	4
	West	0	0	0	0	0
I-5 (Oregon)	North	0	0	0	0	0
	South	2	2	2	2	2
I-5 (California)	North	2	0	0	2	2
	South	0	2	2	2	2

Table U3E. Estimated Peak Hour Traffic Counts per Direction

Road Segment	Direction	Existing Conditions [1]			Proposed Action			Partial Removal			Fish Passage			Remove Two Dams		
		Auto [2]	Medium Trucks [2]	Heavy Trucks [2]	Auto	Medium Trucks	Heavy Trucks [3]	Auto	Medium Trucks	Heavy Trucks [3]	Auto	Medium Trucks	Heavy Trucks [3]	Auto	Medium Trucks	Heavy Trucks [3]
Topsy Grade Rd [4]	North	6	4	1	6	4	5	6	4	5	6	4	1	6	4	1
	South	6	4	1	51	4	1	47	4	1	26	4	5	26	4	5
OR 66 [4]	East	15	9	2	15	9	6	15	9	6	15	9	6	15	9	6
	West	15	9	2	60	9	2	56	9	2	35	9	2	35	9	2
US 97 [4]	North	106	90	120	106	90	124	106	90	124	106	90	120	106	90	120
	South	106	90	120	151	90	120	147	90	120	126	90	120	126	90	120
Ager Rd	North	6	4	1	6	4	1	6	4	1	6	4	3	6	4	3
	South	6	4	1	6	4	2	6	4	2	6	4	1	6	4	1
Copco Rd [5]	East	9	0	4	125	0	4	123	0	4	39	0	8	105	0	6
	West	9	0	4	9	0	13	9	0	9	9	0	4	9	0	8
I-5 (Oregon) [5]	North	848	214	159	848	214	159	848	214	159	848	214	159	848	214	159
	South	848	214	159	964	214	159	962	214	159	878	214	161	944	214	163
I-5 (California) [5]	North	542	0	218	658	0	218	656	0	218	572	0	220	638	0	220
	South	542	0	218	542	0	228	542	0	224	542	0	220	542	0	224

Notes:

[1] See Existing Conditions table for PHT distribution references.

[2] TNM vehicle classification: Auto = cars and light duty trucks, Medium Trucks = all cargo vehicles with two axles and six tires; Heavy trucks - all cargo vehicles with three or more axles.

[3] All haul trucks assumed to be Heavy Trucks (3 axles or more).

[4] Workers for J.C. Boyle assumed to travel from Klamath Falls. Maximum number of construction workers for J.C. Boyle added to the Auto category for Topsy Grade Rd, OR 66, and US 97

[5] Workers for Iron Gate, Copco 1, and Copco 2 assumed to travel from Medford or Yreka. Maximum number of construction workers for the three facilities added to the Auto category for Copco Rd and I-5.

Construction workers are double counted in the Oregon and California segments of I-5 for conservative estimate.

Table U3F. 1-Hr Leq Noise Levels Near Roadways (dBA)

Road Segment	Existing / No Action (Baseline)		Proposed Action		Partial Removal		Fish Passage at Four Dams		Fish Passage at Two Dams	
	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft
Topsy Grade Rd	53	42	56	45	Less impact than Alt 2		56	44	56	44
OR 66	60	49	62	51			62	50	62	50
US 97	75	64	76	64			76	64	76	64
Ager Rd	53	42	54	43			54	43	53	42
Copco Rd	58	46	63	51			60	49	62	51
I-5 (Oregon)	77	66	77	66			77	66	77	66
I-5 (California)	76	66	77	66			77	66	77	66

Increase in 1-Hr Leq Noise Level Above Existing Conditions (dBA)

Road Segment	Significance Criteria (dBA)		Proposed Action		Partial Removal		Fish Passage at Four Dams		Fish Passage at Two Dams	
			50 ft	500 ft	50 ft	500 ft	50 ft	500 ft	50 ft	500 ft
Topsy Grade Rd	OR	10	3	3	Less impact than Alt 2		3	3	3	3
OR 66	OR	10	2	2			1	1	1	1
US 97	OR	10	0	0			0	0	0	0
Ager Rd	CA	12	1	1			3	3	0	0
Copco Rd	CA	12	5	5			2	2	4	4
I-5 (Oregon)	OR	10	0	0			0	0	0	0
I-5 (California)	CA	12	0	0			0	0	0	0

The increase in Leq may appear different when subtracting the existing 1-hour Leq from project 1-hour Leq values due to rounding.