Appendix N
Greenhouse Gas Emission Impacts

N.1 Assessment Methods

This section describes the methodology used to develop the greenhouse gas (GHG) emission inventories and the comparison of the analysis results for the project site activities to the California Environmental Quality Act significance thresholds.

N.1.1 Emission Calculation Methodology

The GHG emission sources that were estimated as part of this analysis include the following:

- Exhaust from off-road (onsite) mobile construction equipment and stationary sources (e.g., generators)
- Exhaust from on-road (offsite) mobile vehicles, including haul trucks and construction worker commuting
- Methane (CH_4) emissions that could occur from impounded water at the reservoirs
- Possible emissions that could occur from replace the hydroelectric dams with non-renewable power

Emissions of carbon dioxide (CO_2), CH_4, and nitrous oxide (N_2O) were estimated to evaluate GHG impacts. Non-CO_2 pollutants have global warming potential (GWP) factors that reflect the degree to which these pollutants affect climate change, as compared to CO_2. The product of each GHG emissions and its GWP is known as Carbon Dioxide equivalent (CO_2e). The value of GWPs is continually being modified by the Intergovernmental Panel on Climate Change (IPCC) as climate change science is refined. Although the IPCC is currently working on the Fifth Assessment Report, most mandatory and voluntary reporting registries require the use of the GWPs published in the Second Assessment Report (IPCC 1996); therefore, the GWPs from the Second Assessment Report were used to maintain consistency with the international standard.

Annual emissions for each year of construction were estimated from appropriate emission factors, number of facilities and features being worked, and the associated schedules that were provided by the project consultants. The following sections provide additional discussion of emission estimation methodologies used for each source group.

N.1.1.1 On-Site (Off-Road) Equipment Engine Exhaust Emissions

Emissions would occur from the combustion of fuel during operation of the off-road construction equipment at each of the dams. As was previously stated, separate emission factor models (i.e., OFFROAD2007 and NONROAD2008a) are used to estimate emissions in California and Oregon.

Preliminary estimates of the type, size (horsepower), and quantity of construction proposed to be used at each of the dam locations was provided by the project consultants. Engine load factors are also incorporated into the emission factor models. Emission factors for each piece of equipment were then selected based on the equipment type (e.g., cranes, excavators, loaders, etc.) and the engine size. It was conservatively assumed that all equipment located at a dam site could operate simultaneously for the entire shift. Iron Gate would have a maximum operating schedule of 14 hours per day, Copco 1 would operate 16 hours per day, and Copco 2 and J.C. Boyle would operate eight hours per day. The total hours of operation for each piece of equipment was also provided with the equipment list provided by the project consultants. Annual emissions were then calculated from the total hours of operation.

In addition to the mobile construction equipment, several stationary generators would be present at each of the dam locations to provide power for electric-operated equipment. Emission factors from Chapter 3.3 (U.S. Environmental Protection Agency 1995) of AP-42 were used to estimate emissions from these generators.

N.1.1.2 Off-Site (On-Road) Haul Truck Engine Exhaust Emissions and Paved Road Dust

The haul truck engine exhaust emissions were calculated based on EMFAC2007 and MOBILE6.2 emission factors for heavy-duty diesel trucks in Siskiyou County, California and Klamath County, Oregon, respectively. Information on the project total round trips was provided by the project consultants. The total project trips were assumed to occur evenly throughout the project schedule. The total vehicle miles traveled was determined from the number of trips and estimated distance to haul each component (e.g., earth, concrete, metal, etc.).

Emission factors vary by year based on changes in the vehicle fleet mix by older engines retiring from service and improved emission control technologies and standards in newer engines joining the fleet. As a result, two different emission factors are provided by location (state) and pollutant to reflect these changes in the fleet mix.

N.1.1.3 Construction Worker Commuting

Emissions associated with construction workers commuting to and from the various dam locations were also estimated for each alternative. It was assumed that construction worker vehicles would consist of a mix of passenger cars and light-duty trucks. The combination of diesel and gasoline (catalyst and non-catalyst) vehicles from the various

emission factor models was retained in the emission factor estimates. As explained in Section N.1.1.2 for trucks, the EMFAC2007 and MOBILE6.2 emission factor models were used to estimate emissions.

N.1.1.4 Methane Emissions from Reservoirs

Methane emissions could also occur from impounded water at the reservoirs. The Karuk Tribe (2006) estimated the total amount of CH_4 released from Keno, J.C. Boyle, Copco, and Iron Gate reservoirs in its comments on the Draft Environmental Impact Statement (EIS) for relicensing and/or decommissioning of the Klamath Hydroelectric Project. The emissions estimation method presented by the Karuk Tribe was adapted for this analysis to estimate CH_4 emissions from impounded water. Emissions were estimated by multiplying the reservoirs' area by areal emissions rates from reservoirs around the world with similar characteristics (poor water quality).

N.1.1.5 Power Replacement

GHG emissions could also occur in the event of any changes in renewable power from the Four Facilities. Since the exact renewable power mix that could exist when the dams are removed, emissions were estimated in two ways: 1) assuming that the existing power mix would be in place and 2) assuming that PacifiCorp met the California Renewable Portfolio Standard (RPS) goal of 33 percent. Emission factors from Emissions & Generation Resource Integrated Database (eGRID) for the PacifiCorp Power Control Area were used to estimate a worst-case scenario assuming that the power grid would not change between now and 2020. Emission factors were then developing assuming that the renewable power mix would increase from approximately nine percent (current mix) to 33 percent by 2020.

The Federal Energy Regulatory Commission EIS (2007) provided power generation estimates for the different alternatives. These annual average power estimates were used in the analysis to estimate emissions that could occur from power replacement.

N.2 Emission Inventories

Emission inventories were completed for each of the dam locations and alternatives as described in the previous sections. Table N-1 summarizes emissions that could occur from dam removal activities or the construction of fish passage, as well as possible power replacement emissions. The table does not include CH_4 emissions that would occur from impounded water in the reservoirs.

Table N-1. Impact Summary Table (Without Methane Generation from Reservoirs)

Alternative	Emissions (metric tons CO_2e/year)		
	Deconstruction	Power Replacement	
		(Current Resource Mix)	(33% RPS)
2	8,747	396,575	341,539
3	7,840	396,575	341,539
4	1,600	87,525	75,431
5	7,789	139,644	120,320

Key:
CO_2e = carbon dioxide equivalent

Table N-2 summarizes power replacement emissions with CH_4 generation from the reservoirs. The Karuk Tribe (2006) estimated a range of emissions that could occur based on the conditions that could occur; therefore, Table N-2 shows the predicted range of emissions that could occur based on the amount of CH_4 that could be emitted from the reservoirs.

In Alternatives 2 and 3, the dams would be removed in their entirety and the reservoirs would cease to exist; therefore, the total expected impact from power replacement would be reduced by the amount of CH_4 that would no longer be emitted from the impounded water. Although the dams would remain in place in Alternative 4, the amount of power that could be produced would be reduced from current conditions because water would be needed to support fish passage. The amount of CH_4 emitted from the reservoirs is added to the emissions that could occur from the expected reduction in renewable power. In Alternative 5, the J.C. Boyle Reservoir would remain, but emissions from the other reservoirs would be eliminated. As with Alternative 4, CH_4 emissions from the reservoirs are added to the emissions that could occur from power replacement.

Table N-2. Impact Summary Table (With Methane Generation from Reservoirs)

Alternative	Power Replacement and CH_4 from Impounded Reservoirs Emissions (metric tons CO_2e/year)			
	(Current Resource Mix)		(33% RPS)	
	Low[1]	High[2]	Low[1]	High[2]
2	392,575	382,575	337,539	327,539
3	392,575	382,575	337,539	327,539
4	91,525	101,525	79,431	89,431
5	140,344	142,644	121,020	123,320

Notes:
[1] Low power replacement refers to minimum CH_4 emissions predicted to be emitted by the reservoirs.
[2] High power replacement refers to maximum CH_4 emissions predicted to be emitted by the reservoirs.
Key:
CH_4 = methane
CO_2e = carbon dioxide equivalent

Detailed emission inventories for each of the alternatives are included as attachments to this appendix.

N.3 References

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License. Volume I. Klamath Hydroelectric FERC Project No. 2082-0278. November.

Intergovernmental Panel on Climate Change (IPCC). 1996. Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, Great Britain: Press Syndicate of the University of Cambridge.

Karuk Tribe of California. 2006. Comments on Draft EIS in Klamath Hydroelectric Project Docket for Filing: P-2082-027 (Klamath). Submitted to FERC by the Karuk Tribe of California, Orleans, CA. 60 p. Accessed on July 7, 2011. Available online at: http://www.klamathwaterquality.com/documents/karuk_comments_20061201-5040(16445270).pdf.

U.S. Environmental Protection Agency (USEPA). 1995. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42, Fifth Edition. Accessed on January 31, 2011. Available at: http://www.epa.gov/ttn/chief/ap42/.