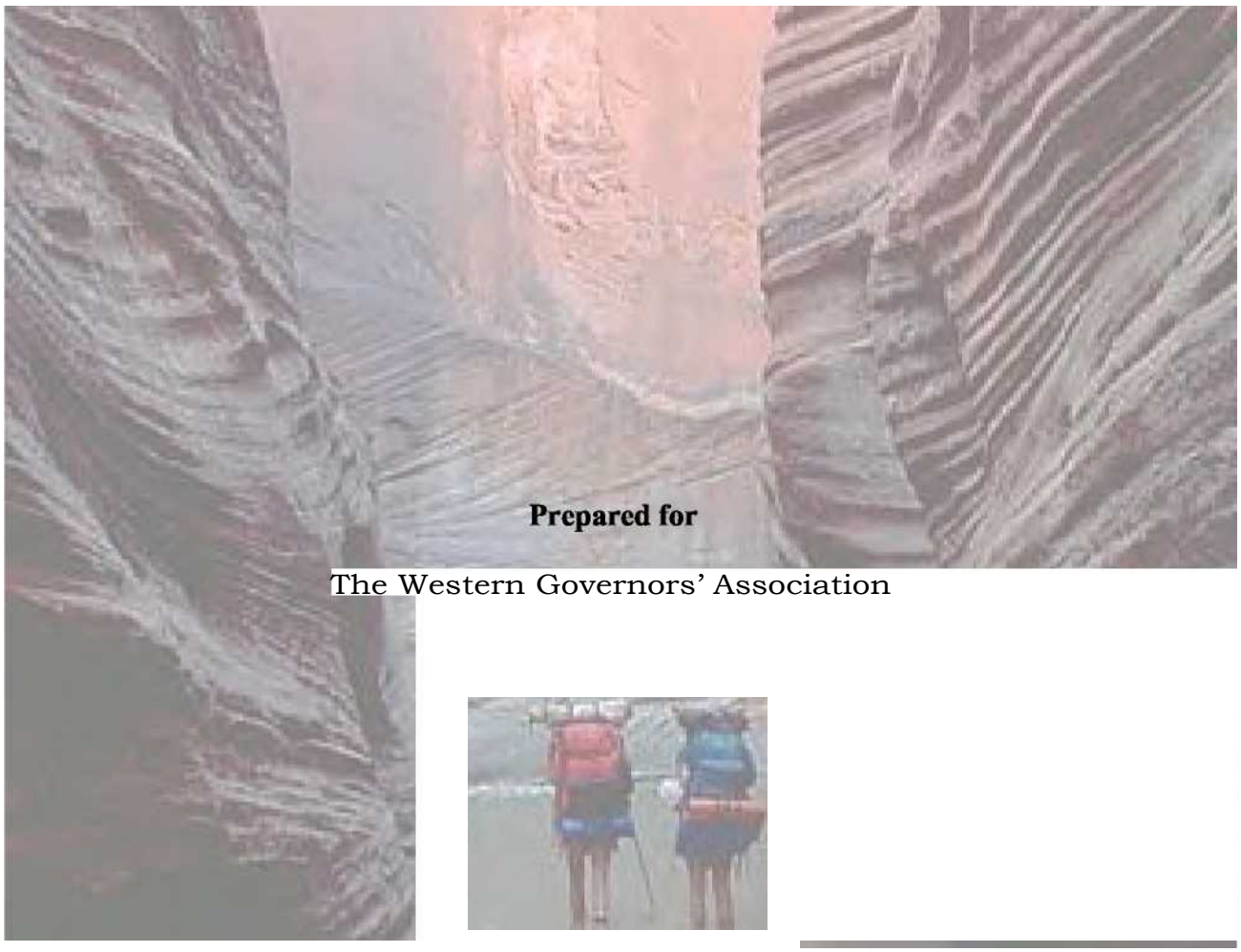
Air Emissions Inventory for Zion National Park



The Western Governors' Association

By

The University of California at Riverside
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Table of Contents

Title	Page No.
Chapter One – Introduction	1
Chapter Two – Park Background Information	8
Chapter Three – Stationary Sources	10
Chapter Four – Area Sources	24
Chapter Five – Mobile Sources	29
Chapter Six – Environmental Benefit of Shuttle Bus System	48
Chapter Seven – Utah Air Quality Rules Review	50
Chapter Eight – Mitigation of Park Emissions	52
Appendix A – Emission Factors for Estimation of Park Emissions	A-1
Appendix B – Data Excel Worksheets	B-1
Appendix C – Inputs for Mobile Source Emission Modeling	C-1
Appendix D – Miscellaneous Documents Provided by Zion Park Personnel	D-1
Appendix E – August 16-19, 2000 Field Notes	E-1

Chapter One - Introduction

In mid-August, 2000, the Center for Environmental Research and Technology within the College of Engineering at the University of California's Riverside Campus (CE-CERT) was contracted by the Western Governor's Association to inventory the air emissions of criteria pollutants within eight National Parks. The inventories are to include point and area sources as well as mobile sources of emissions operating within Park boundaries. In consideration of the budget and the timeframe for preparing the inventories, it was mutually agreed that on-site data collection for characterization of the in-Park vehicle fleet would be limited to two Parks. It was also agreed that these two Parks would need to be surveyed on or before labor-day weekend in order to characterize the in-Park vehicle fleet during the summer visitation period. Zion and Arches National Parks were selected because they were felt to be generally representative of the other six parks. Following the on-site vehicle fleet characterization studies, on-site emissions and activity data were collected at all eight National Parks.

The CE-CERT survey team initially visited Zion and Arches National Parks between August 16 and 22, 2000. This was the busiest time of the year for Park staff, and staff resources were especially strained due to efforts to control wildfires that were occurring in a number of the Western states. At the request of the National Park Service, CE-CERT's survey efforts were limited to direct data collection on the in-Park vehicle fleet composition and in-Park driving patterns. CE-CERT staff then returned on November 2, 2000 and met with Park staff to identify and obtain data related to stationary, area, and mobile source emissions in Zion National Park.

Based on the data received during these two in-park visits, CE-CERT has developed an inventory of emissions occurring from sources operating within Zion National Park. The report is organized to first provide the reader with an overall sense of the total in-Park emissions, the contribution made by each source category, and the magnitude of the Park's total emissions to the totals for neighboring counties (see Tables 1.1-1.5). Chapter Two provides a brief discussion of the history of Zion National Park. Chapters Three through Five provide individual descriptions of the three major emission source classifications; Stationary, Area, and Mobile. At the end of each chapter, spreadsheets are included that provide information on the individual emission sources and the calculations employed to develop a best estimate of their emissions. Within each of these chapters, the emissions have been calculated as monthly averages for two periods of the year: April through October, and November through March. The first period corresponds to the Park's busiest season when the Zion Canyon shuttle bus system is in operation and, the second period covers the timeframe when the shuttle bus system is not operated. Chapter Six evaluates the environmental benefit of the propane-powered shuttle bus system recently initiated within the Park. The report concludes with Chapter Seven, which contains the results of a review of Utah's air regulations and their applicability to emissions sources within the Park. Appendix A provides a listing of the emission factors used to develop this emission inventory. Appendix B provides the Excel worksheets used to develop much of the data collected into the necessary formats. Appendix C provides the inputs used in the mathematical modeling conducted to develop the mobile source

emission estimates. Appendix D is a compilation of data provided by Park personnel that were used in the emissions determinations. Appendix E contains the pertinent excerpts from the field log maintained by CE-CERT staff during the August 2000 Park visit. A CD is also included in an envelope attached to the inside of the back cover of this report. The CD contains all of the report with the exception of Appendix D and the Cummins engine test report in Appendix C. The CD is intended to facilitate manipulation of the data into different groupings for further analyses. It also allows the inventory to be updated in the event that emission factors, used in this report, are updated, more exact information on in-Park sources is developed, or new sources are added to the Park's inventory. In addition, the CD contains a compilation of Utah's air quality regulations.

Table 1.1a: Summary of Summertime Emissions in Zion National Park

			TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman		660.3	660.3	4,359.4	133.4	4,821.1	67.6
	South		498.2	498.2	3,297.6	37.4	3,637.4	5.8
	Lava Point		46.7	46.7	309.2	3.5	341.0	0.5
	Back Country		0.0	0.0	0.0	0.0	0.0	0.0
		Sub-Total	1,205.3	1,205.3	7,966.1	174.4	8,799.6	73.9
Facilities	Zion Lodge		102.4	100.0	12.6	155.6	27.2	457.9
	Old Visitor Center		0.1	0.1	0.1	3.8	0.5	2.7
	Maintenance Yard		0.2	0.2	87.3	5.1	0.7	4.4
	Shuttle Bus Maintenance Yard		0.0	0.0	933.5	0.0	0.0	0.0
	W atchman Bone Yard		346.0	346.0	2,290.0	26.0	2,526.0	4.0
	Grotto House		1.2	1.2	2.1	0.1	9.2	0.0
	Visitor Center		0.0	0.0	0.0	0.0	0.0	0.0
	Environmental Education Center		0.0	0.0	0.0	0.0	0.0	0.0
	Kolob Canyon Visitor Center		0.0	0.0	0.0	0.0	0.0	0.0
	East/South/New Walk Entrances		0.0	0.0	0.0	0.0	0.0	0.0
	Rockville Sewage Treatment		0.0	0.0	0.0	0.0	0.0	0.0
	Park Landfill		0.0	0.0	0.0	0.0	0.0	0.0
		Sub-Total	449.9	447.5	3,325.6	190.6	2,563.7	468.9
Residential	Oak Creek		18.4	18.4	31.8	3.5	138.9	1.6
	W atchman		15.4	15.4	26.5	3.7	115.8	**1.9**
	Kolob Canyon		1.2	1.2	2.1	0.4	9.3	0.2
	Pine Creek		6.1	6.1	10.6	0.6	46.2	0.1
	East Entrance		6.1	6.1	10.6	0.8	46.2	0.3
	Lava Point		0.0	0.0	0.0	0.0	0.0	0.0
	Firepit		0.0	0.0	0.0	0.3	0.0	0.2
		Sub-Total	47.3	47.3	81.7	9.3	356.4	4.2
Evaporative	Solvent Use				29.0			
		Sub-Total	0.0	0.0	29.0	0.0	0.0	0.0
Road Maintenance	Paving				33,320.0			
		Sub-Total	0.0	0.0	33,320.0	0.0	0.0	0.0
Other Area	Cinder Piles		0.7	0.4	0.0	0.0	0.0	0.0
	Prescribed Burning		10,840.2	7,917.0	3,684.5	1,218.0	42,630.0	30.5
	Wildfires		34,884.0	24,418.8	26,060.4	8,208.0	287,280.0	205.2
	Re-entrained Dust, Tire, & Brake W ear		15,040.0	3,080.2	0.0	0.0	0.0	0.0
		Sub-Total	60,764.9	35,416.3	29,744.9	9,426.0	329,910.0	235.7
On-Road	Visitor Passenger Vehicles		46.3	46.3	6036.9	1851.8	31295.6	0.0
	Tour Buses		16.2	16.2	134.8	232.4	521.6	0.0
	Government Vehicles		15.8	15.8	586.7	296.2	3083.5	0.0
	Shuttle Buses		6.8	6.8	415.7	**1190.2**	36.3	0.0
		Sub-Total	85.0	85.0	7174.1	3570.6	34937.1	0.0
Off-Road	Misc. Equipment		0.6	0.6	42.0	0.3	107.8	0.1
		Sub-Total	0.6	0.6	42.0	0.3	107.8	0.1
	Total Emissions from Park (lbs/month)		62,552.9	37,201.9	81,683.3	13,371.2	376,674.5	782.8
	Total Emissions from Park (tons/day)		1.04	0.62	1.36	0.22	6.28	0.01
	Total Annual Tons of Emissions (W inter plus Summer)		341	207	428	62	1,770	3

Table 1.1b: Summary of Summertime Emissions in Zion National Park (less wildfires)

			TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	**NOX** (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman		660.3	660.3	4,359.4	133.4	4,821.1	67.6
	South		498.2	498.2	3,297.6	37.4	3,637.4	5.8
	Lava Point		46.7	46.7	309.2	3.5	341.0	0.5
	Back Country		0.0	0.0	0.0	0.0	0.0	0.0
		Sub-Total	1,205.3	1,205.3	7,966.1	174.4	8,799.6	73.9
Facilities	Zion Lodge		102.4	100.0	12.6	155.6	27.2	457.9
	Old Visitor Center		0.1	0.1	0.1	3.8	0.5	2.7
	Maintenance Yard		0.2	0.2	87.3	5.1	0.7	4.4
	Shuttle Bus Maintenance Yard		0.0	0.0	933.5	0.0	0.0	0.0
	Watchman Bone Yard		346.0	346.0	2,290.0	26.0	2,526.0	4.0
	Grotto House		1.2	1.2	2.1	0.1	9.2	0.0
	Visitor Center		0.0	0.0	0.0	0.0	0.0	0.0
	Environmental Education Center		0.0	0.0	0.0	0.0	0.0	0.0
	Kolob Canyon Visitor Center		0.0	0.0	0.0	0.0	0.0	0.0
	East/South/New Walk Entrances		0.0	0.0	0.0	0.0	0.0	0.0
	Rockville Sewage Treatment		0.0	0.0	0.0	0.0	0.0	0.0
	Park Landfill		0.0	0.0	0.0	0.0	0.0	0.0
		Sub-Total	449.9	447.5	3,325.6	190.6	2,563.7	468.9
Residential	Oak Creek		18.4	18.4	31.8	3.5	138.9	1.6
	Watchman		15.4	15.4	26.5	3.7	115.8	1.9
	Kolob Canyon		1.2	1.2	2.1	0.4	9.3	0.2
	Pine Creek		6.1	6.1	10.6	0.6	46.2	0.1
	East Entrance		6.1	6.1	10.6	0.8	46.2	0.3
	Lava Point		0.0	0.0	0.0	0.0	0.0	0.0
	Firepit		0.0	0.0	0.0	0.3	0.0	0.2
		Sub-Total	47.3	47.3	81.7	9.3	356.4	4.2
Evaporative	Solvent Use				29.0			
		Sub-Total	0.0	0.0	29.0	0.0	0.0	0.0
Road Maintenance	Paving				33,320.0			
		Sub-Total	0.0	0.0	33,320.0	0.0	0.0	0.0
Other Area	Cinder Piles		0.7	0.4	0.0	0.0	0.0	0.0
	Prescribed Burning		10,840.2	7,917.0	3,684.5	1,218.0	42,630.0	30.5
	Wildfires							
	Re-entrained Dust, Tire, & Brake Wear		15,040.0	3,080.2	0.0	0.0	0.0	0.0
		Sub-Total	25,880.9	10,997.5	3,684.5	1,218.0	42,630.0	30.5
On-Road	Visitor Passenger Vehicles		46.3	46.3	6036.9	1851.8	31295.6	0.0
	Tour Buses		16.2	16.2	134.8	232.4	521.6	0.0
	Government Vehicles		15.8	15.8	586.7	296.2	3083.5	0.0
	Shuttle Buses		6.8	6.8	415.7	1190.2	36.3	0.0
		Sub-Total	85.0	85.0	7174.1	3570.6	34937.1	0.0
Off-Road	Misc. Equipment		0.6	0.6	42.0	0.3	107.8	0.1
		Sub-Total	0.6	0.6	42.0	0.3	107.8	0.1
	Total Emissions from Park (lbs/month)		27,668.9	12,783.1	55,622.9	5,163.2	89,394.5	577.6
	Total Emissions from Park (tons/day)		0.46	0.21	0.93	0.09	1.49	0.01
	Total Annual Tons of Emissions (Winter plus Summer)		219	122	336	34	764	3

Table 1.2a: Summary of Summertime Percentages

			TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman		1.06%	1.77%	5.34%	1.00%	1.28%	8.64%
	South		0.80%	1.34%	4.04%	0.28%	0.97%	0.74%
	Lava Point		0.07%	0.13%	0.38%	0.03%	0.09%	0.07%
	Back Country		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		Sub-Total	1.93%	3.24%	9.75%	1.30%	2.34%	9.44%
Facilities	Zion Lodge		0.16%	0.27%	0.02%	1.16%	0.01%	58.50%
	Old Visitor Center		0.00%	0.00%	0.00%	0.03%	0.00%	0.34%
	Maintenance Yard		0.00%	0.00%	0.11%	0.04%	0.00%	0.56%
	Shuttle Bus Maintenance Yard		0.00%	0.00%	1.14%	0.00%	0.00%	0.00%
	Watchman Bone Yard		0.55%	0.93%	2.80%	0.19%	0.67%	0.51%
	Grotto House		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Visitor Center		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Environmental Education Center		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Kolob Canyon Visitor Center		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	East/South/New Walk Entrances		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Rockville Sewage Treatment		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Park Landfill		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		Sub-Total	0.72%	1.20%	4.07%	1.43%	0.68%	59.91%
Residential	Oak Creek		0.03%	0.05%	0.04%	0.03%	0.04%	0.20%
	Watchman		0.02%	0.04%	0.03%	0.03%	0.03%	0.24%
	Kolob Canyon		0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
	Pine Creek		0.01%	0.02%	0.01%	0.00%	0.01%	0.01%
	East Entrance		0.01%	0.02%	0.01%	0.01%	0.01%	0.03%
	Lava Point		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Firepit		0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
		Sub-Total	0.08%	0.13%	0.10%	0.07%	0.09%	0.53%
Evaporative	Solvent Use		0.00%	0.00%	0.04%	0.00%	0.00%	0.00%
		Sub-Total	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%
Road Maintenance	Paving		0.00%	0.00%	40.79%	0.00%	0.00%	0.00%
		Sub-Total	0.00%	0.00%	40.79%	0.00%	0.00%	0.00%
Other Area	Cinder Piles		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Prescribed Burning		17.33%	21.28%	4.51%	9.11%	11.32%	**3.89%**
	Wildfires		55.77%	65.64%	31.90%	61.39%	76.27%	26.21%
	Re-entrained Dust, Tire, & Brake Wear		24.04%	**8.28%**	0.00%	0.00%	0.00%	0.00%
		Sub-Total	97.14%	95.20%	36.41%	70.49%	87.58%	30.10%
On-Road	Visitor Passenger Vehicles		0.07%	0.12%	7.39%	13.85%	8.31%	0.00%
	Tour Buses		0.03%	0.04%	0.16%	1.74%	0.14%	0.00%
	Government Vehicles		0.03%	0.04%	0.72%	2.22%	0.82%	0.00%
	Shuttle Buses		0.01%	0.02%	0.51%	**8.90%**	0.01%	0.00%
		Sub-Total	0.14%	0.23%	**8.78%**	26.70%	**9.28%**	0.00%
Off-Road	Misc. Equipment		0.00%	0.00%	0.05%	0.00%	0.03%	0.01%
		Sub-Total	0.00%	0.00%	0.05%	0.00%	0.03%	0.01%
			0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total Emissions from Park		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 1.2b: Summary of Summertime Percentages (less wildfires)

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	2.39%	5.17%	7.84%	**2.58%**	**5.39%**	11.71%
	South	1.80%	3.90%	**5.93%**	0.73%	4.07%	1.00%
	Lava Point	0.17%	0.37%	0.56%	0.07%	0.38%	0.09%
	Back Country	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	4.36%	9.43%	14.32%	3.38%	**9.84%**	12.80%
Facilities	Zion Lodge	0.37%	0.78%	0.02%	3.01%	0.03%	79.28%
	Old Visitor Center	0.00%	0.00%	0.00%	0.07%	0.00%	0.46%
	Maintenance Yard	0.00%	0.00%	0.16%	0.10%	0.00%	0.76%
	Shuttle Bus Maintenance Yard	0.00%	0.00%	1.68%	0.00%	0.00%	0.00%
	Watchman Bone Yard	1.25%	2.71%	4.12%	0.50%	2.83%	0.69%
	Grotto House	0.00%	0.01%	0.00%	0.00%	0.01%	0.00%
	Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Environmental Education Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Kolob Canyon Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	East/South/New Walk Entrances	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Rockville Sewage Treatment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Park Landfill	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	1.63%	3.50%	**5.98%**	3.69%	2.87%	81.19%
Residential	Oak Creek	0.07%	0.14%	0.06%	0.07%	0.16%	0.27%
	Watchman	0.06%	0.12%	0.05%	0.07%	0.13%	0.32%
	Kolob Canyon	0.00%	0.01%	0.00%	0.01%	0.01%	0.04%
	Pine Creek	0.02%	0.05%	0.02%	0.01%	0.05%	0.01%
	East Entrance	0.02%	0.05%	0.02%	0.02%	0.05%	0.04%
	Lava Point	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Firepit	0.00%	0.00%	0.00%	0.01%	0.00%	0.03%
	Sub-Total	0.17%	0.37%	0.15%	0.18%	0.40%	0.72%
Evaporative	Solvent Use	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
Road Maintenance	Paving	0.00%	0.00%	**59.90%**	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	**59.90%**	0.00%	0.00%	0.00%
Other Area	Cinder Piles	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Prescribed Burning	39.18%	61.93%	6.62%	23.59%	47.69%	5.27%
	Wildfires	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Re-entrained Dust, Tire, & Brake Wear	54.36%	24.10%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	93.54%	86.03%	6.62%	23.59%	47.69%	5.27%
On-Road	Visitor Passenger Vehicles	0.17%	0.36%	10.85%	35.87%	35.01%	0.00%
	Tour Buses	0.06%	0.13%	0.24%	4.50%	**0.58%**	0.00%
	Government Vehicles	0.06%	0.12%	1.05%	5.74%	3.45%	0.00%
	Shuttle Buses	0.02%	0.05%	0.75%	23.05%	0.04%	0.00%
	Sub-Total	0.31%	0.67%	12.90%	69.16%	39.08%	0.00%
Off-Road	Misc. Equipment	0.00%	0.00%	0.08%	0.01%	0.12%	0.02%
	Sub-Total	0.00%	0.00%	0.08%	0.01%	0.12%	0.02%
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total Emissions from Park	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 1.3: Summary of Wintertime Emissions in Zion National Park

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	421.7	421.7	2,786.99	**55.6**	3,076.0	22.0
	South	318.9	318.9	2,110.46	24.0	2,328.0	3.7
	Lava Point	18.7	18.7	123.66	1.4	136.4	0.2
	Back Country	0.0	0.0	0.00	0.0	0.0	0.0
	Sub-Total	759.3	759.3	5,021.1	**80.9**	5,540.4	**25.9**
Facilities	Zion Lodge	29.3	28.6	3.6	44.4	7.8	130.7
	Old Visitor Center	0.3	0.3	0.2	11.6	1.6	8.3
	Maintenance Yard	0.2	0.2	52.3	1.8	0.2	4.0
	Shuttle Bus Maintenance Yard	0.0	0.0	0.0	0.0	0.0	0.0
	Watchman Bone Yard	484.4	484.4	3,206.0	36.4	3,536.4	5.6
	Grotto House	0.0	0.0	0.0	0.0	0.0	0.0
	Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	Environmental Education Center	0.0	0.0	0.0	0.0	0.0	0.0
	Kolob Canyon Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	East/South/New Walk Entrances	0.0	0.0	0.0	0.0	0.0	0.0
	Rockville Sewage Treatment	0.0	0.0	0.0	0.0	0.0	0.0
	Park Landfill	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	514.2	513.5	3,262.2	94.2	3,546.0	148.6
Residential	Oak Creek	**58.3**	**58.3**	100.8	11.1	439.7	4.9
	Watchman	49.2	49.2	**85.0**	11.7	370.6	**5.8**
	Kolob Canyon	0.0	0.0	0.0	0.0	0.0	0.0
	Pine Creek	18.4	18.4	31.8	1.7	138.6	0.2
	East Entrance	24.5	24.5	42.4	2.2	184.8	0.3
	Lava Point	0.0	0.0	0.0	0.0	0.0	0.0
	Firepit	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	150.3	150.3	260.0	26.8	1,133.7	11.3
Evaporative	Solvent Use			29.0			
	Sub-Total	0.0	0.0	29.0	0.0	0.0	0.0
Road Maintenance	Paving			33,320.0			
	Sub-Total	0.0	0.0	33,320.0	0.0	0.0	0.0
Other Area	Cinder Piles	0.7	0.4	0.0	0.0	0.0	0.0
	Prescribed Burning	37,540.0	27,460.0	12,760.2	4,232.0	148,200.0	105.8
	Wildfires	0.0	0.0	0.0	0.0	0.0	0.0
	Re-entrained Dust, Tire, & Brake Wear	9,734.1	1,976.8	0.0	0.0	0.0	0.0
	Sub-Total	47,274.9	29,437.2	12,760.2	4,232.0	148,200.0	105.8
On-Road	Visitor Passenger Vehicles	32.3	32.3	1771.0	**1499.5**	20036.7	0.0
	Tour Buses	5.7	5.7	47.1	81.2	182.3	0.0
	Government Vehicles	6.7	6.7	211.2	248.5	1832.8	0.0
	Shuttle Buses	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	44.7	44.7	2029.3	1829.2	22051.8	0.0
Off-Road	Misc. Equipment	0.6	0.6	42.0	0.3	107.8	0.1
	Sub-Total	0.6	0.6	42.0	0.3	107.8	0.1
	Total Emissions from Park (lbs/month)	48,743.9	30,905.5	56,723.8	6,263.5	180,579.6	291.6
	Total Emissions from Park (tons/day)	0.81	0.52	**0.95**	0.10	3.01	0.00
	Total Annual Tons of Emissions (Winter plus Summer)	341	207	428	62	1,770	3

Table 1.4: Summary of Wintertime Percentages

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	0.87%	1.36%	4.91%	0.89%	1.70%	7.53%
	South	0.65%	1.03%	3.72%	0.38%	1.29%	1.26%
	Lava Point	0.04%	0.06%	0.22%	0.02%	0.08%	0.07%
	Back Country	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	1.56%	2.46%	**8.85%**	1.29%	3.07%	**8.87%**
Facilities	Zion Lodge	0.06%	0.09%	0.01%	0.71%	0.00%	44.82%
	Old Visitor Center	0.00%	0.00%	0.00%	0.19%	0.00%	2.84%
	Maintenance Yard	0.00%	0.00%	0.09%	0.03%	0.00%	1.36%
	Shuttle Bus Maintenance Yard	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Watchman Bone Yard	0.99%	1.57%	**5.65%**	**0.58%**	1.96%	1.92%
	Grotto House	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Environmental Education Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Kolob Canyon Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	East/South/New Walk Entrances	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Rockville Sewage Treatment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Park Landfill	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	1.05%	1.66%	**5.75%**	1.50%	1.96%	50.94%
Residential	Oak Creek	0.12%	0.19%	0.18%	0.18%	0.24%	1.68%
	Watchman	0.10%	0.16%	0.15%	0.19%	0.21%	2.00%
	Kolob Canyon	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Pine Creek	0.04%	0.06%	0.06%	0.03%	0.08%	0.08%
	East Entrance	0.05%	0.08%	0.07%	0.04%	0.10%	0.11%
	Lava Point	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Firepit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	0.31%	0.49%	0.46%	0.43%	0.63%	3.87%
Evaporative	Solvent Use	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
Road Maintenance	Paving	0.00%	0.00%	58.74%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	58.74%	0.00%	0.00%	0.00%
Other Area	Cinder Piles	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Prescribed Burning	77.01%	**88.85%**	22.50%	67.57%	82.07%	36.28%
	Wildfires	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Reintrained Dust, Tire, & Brake Wear	19.97%	6.40%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	96.99%	95.25%	22.50%	67.57%	82.07%	36.28%
On-Road	Visitor Passenger Vehicles	0.07%	0.10%	3.12%	23.94%	11.10%	0.00%
	Tour Buses	0.01%	0.02%	0.08%	1.30%	0.10%	0.00%
	Government Vehicles	0.01%	0.02%	0.37%	3.97%	1.01%	0.00%
	Shuttle Buses	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	0.09%	0.14%	**3.58%**	29.20%	12.21%	0.00%
Off-Road	Misc. Equipment	0.00%	0.00%	0.07%	0.01%	0.06%	0.03%
	Sub-Total	0.00%	0.00%	0.07%	0.01%	0.06%	0.03%
	Total Emissions from Park	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 1.5: Comparison of Zion National Park Emissions with Surrounding Counties

		Annual Emissions in Tons per Year					
Region	**Comment**	**TSP**	**PM10**	**VOC**	**NOx**	**CO**	**SOx**
Zion Park	Wildfires Included	341	207	428	62	1,770	3
Zion Park	Wildfires Not Included	219	122	336	34	764	3
Washington County	Contains most of Zion Park	no value	3,640	20,759	3,234	33,300	560
Kane County	Contains some of Zion Park	no value	544	6,041	412	3,941	170
Iron County	Contains tiny part of Zion Park	no value	2,411	12,053	3,437	21,439	1,667
State of Utah	Statewide Totals	no value	139,147	500,358	201,977	913,739	132,187
Zion Park Compared to Washington County		n/a	5.7%	2.1%	1.9%	5.3%	0.6%
Zion Park Less Wildfires Compared to Wash. Co.		n/a	3.4%	1.6%	1.0%	2.3%	0.5%
Zion Park Compared to Statewide Totals		n/a	0.15%	0.09%	0.03%	0.19%	0.003%
Zion Park Less Wildfires Compared to Statewide		n/a	0.09%	0.07%	0.02%	0.08%	0.002%

Chapter Two - Park Background Information

Zion National Park encompasses some 229 square miles located in the southwestern corner of Utah. Zion was designated as the Mukuntuweap National Monument by President Taft in 1909 and was later upgraded and renamed Zion National Park in 1919. Zion, like its older sibling, the Grand Canyon, and its younger sibling, Bryce Canyon, displays the power of natural forces such as wind, water, faulting, and volcanic activity. These forces have created towering cliffs, deep narrow canyons, and a variety of rock formations. Geologically, the terrain consists of nine distinct layers, or formations, of sediment that date back as far as 240 million years. These formations, in chronological order, are the Kaibab, Moenkopi, Chinle, Moenave, Kayenta, Navajo, Temple Cap, Carmel, and Dakota. Within Zion, the Navajo formation of sandstone reaches its maximum thickness of some 2,400 feet. Over the centuries, the North Fork of the Virgin River has eroded through hundreds of feet of the sandstone formation leaving a narrow canyon with almost vertical walls known appropriately as the "Narrows." Tracks of dinosaurs can be found preserved in the Kayenta formation.

Zion is home to 68 species of mammals, 36 species of reptiles, 7 species of amphibians, and 271 species of birds. Examples of these residents include elk, mule deer, desert bighorn sheep, mountain lion, bobcat, coyote, gray fox, badger, weasel, ringtail cat, gray rock squirrel, pocket gopher, pack rat, porcupines, beaver, collared lizards, chuckwallas, western skinks, banded geckos, desert horned lizard, short-horned lizard, western rattlesnake, Sonoran Mountain king snake, the black-and-white-banded king snake, tarantulas, golden eagles, peregrine falcons, black-headed grosbeaks, lazuli buntings, canyon wrens, hummingbirds, ravens, stellar jays, and roadrunners.

Zion has also been home to the Anasazi (Pueblos) and later to the Paiute Indian tribes before being "discovered" and settled by the Mormons in the 1850's and 1860's. In 1925, the Zion Lodge was constructed and, in 1930, the Zion-Mt. Carmel Highway was completed. The highway included the uniquely engineered 1.1 mile long Zion Tunnel. This roadway is now part of Utah state highway 9 running diagonally for approximately 11 miles across the Southeastern corner of the park. Highway 9 is one of the main routes for visitors to Bryce Canyon National Park. The Civilian Conservation Corps created by President Franklin D. Roosevelt in 1933 built many stone structures within the park prior to World War II. Continuing construction resulted in the present 31.1 miles of paved roadway within the park. Most recently, a new visitors center has been constructed at the South entrance to the park. (See Map 5.1a)

Zion National Park is visited by some 2.5 million people each year. There are four entrances into the park. The South entrance is the main entrance located at Springdale, Utah along the south-central border of the park. Highway 9, referred to as the Zion-Mt. Carmel Highway, connects the South Entrance to the East Entrance. The East Entrance is located along the southeastern border of the park and is the second most used entrance to the Zion Canyon section of the Park. From the town of Virgin, Utah the road to the Upper Kolob Plateau enters and exits the Park on two occasions at approximately mid-latitude. It is the least used entrance to the Park. The fourth and final entrance is located

along the northeast border of the Park. It is accessed directly from Interstate 15 via the Kolob Canyon road.

The Zion Canyon section is the most heavily visited area of the Park. A study conducted early in the last decade (Machlis, 1992) indicates this area is visited by 95% of the Parks visitors. That same study showed visitors felt the traffic and associated congestion were a significant negative factor. In an effort to ensure a quality experience for visitors to Zion National Park and to reduce the environmental pollution associated with the increasing vehicle traffic, a shuttle bus program was developed. In May 2000, the program was initiated using a fleet of propane-powered buses. Each day some 16 buses from the 30-bus fleet provide an average of 120 round trips per day between the newly constructed visitors' center and the area known as the Temple of Sinawava. With the exception of guests staying at the Zion Lodge and those who are physically unable to use the shuttles, the Zion Canyon road between the Canyon Junction and the Temple of Sinawava will now only be accessible to visitors via shuttle bus and tour buses from April through October (note: starting in April 2001 tour buses will be required to make advance reservations for meals or lodging in order to travel to the lodge complex). This report also includes an estimate of the air emissions benefit of this shuttle system.

Chapter Three - Stationary Sources

Potential stationary sources within Zion National Park were identified as the campgrounds, Zion lodge, Park headquarters, the Park maintenance yard, the shuttle bus maintenance yard, the Watchman bone yard, the new visitors' center, the environmental education center, the Kolob Canyon visitors' center, the Grotto house, and the individual residential areas.

Campgrounds

Camping within Zion National Park occurs in three locations: Watchman campground, South campground, and Lava Point campground. The Watchman and South campgrounds are located near the south entrance to the park. The Watchman campground consists of 169 campsites including 92 electrified RV sites. The South campground consists of 128 non-electrified campsites. The Lava Point campground is located off the Kolob Terrace road and consists of 6 campsites. All of the 303 campsites have fire rings and allow the burning of imported wood. While backcountry camping occurs within the Park, wood burning is not allowed. Therefore, no emissions are attributed to backcountry camping. Based on information provided in response to an earlier air quality/emissions survey, 80% of the campers in the campgrounds utilize campfires during the cooler months and 50% utilize campfires during the rest of the year. Observation during the August on-site visit by CE-CERT personnel indicated a 20 to 30% utilization of campfires at that time. For this inventory, the 80% usage estimate was applied to the November through March period and the 50% estimate to the April through October period. Bundles of Ponderosa pine firewood, estimated at 12 to 15 lbs each, are sold outside the Park by a number of vendors. For purposes of emission calculations, CE-CERT assumes a campfire combusts a 15 lb bundle of firewood each day. Propane usage by RV's was estimated based upon phone interviews with RV dealers in the Los Angeles area, as was gasoline consumption for on-board electricity generators. Since the number of RV campers exceeded the number of available sites by approximately 10% during the April through October period, it is assumed that 10% of the RV's will generate their own electricity during that timeframe. Since the number of electrified sites is greater than the number of RV's during the November through March period, it is assumed that no on-board electricity generation will occur during that timeframe.

It should be noted that much of the information related to campsite fires and RV generators was speculative based on estimates of park personnel, which varied widely in some cases, and very limited observations by CE-CERT personnel. If this is determined to be an important source of emissions, further efforts should be made to accurately quantify campsite activities by direct studies.

Zion Lodge

Zion lodge is a complex consisting of 121 lodging units for guests, a souvenir shop, employee lodging consisting of 66 two-person rooms and 10 mobile home sites, employee cafeteria, main kitchen, visitor dining room, and a fast-food take out cafe.

A 1.9 MM Btu fuel oil fired boiler is located in the basement of the main lodge. On an annual basis, it uses an average of 1877 gallons of fuel oil (250 ppm sulfur) per month to provide steam to the main kitchen and employee cafeteria as well as heating for the employee cafeteria. On an annual basis, the entire complex uses an average of 5125 gallons a month of propane for space heating, water heating, laundry, and cooking. Wood burning does not occur within the complex. Cooking equipment consists of ovens, grills, broilers, deep fat fryers, pizza cooker, a cold-surface hot dog cooker, and a cold surface chain operated hamburger cooker. Vents located over the grills, broilers, and deep fat fryers are equipped with metalbestos filters that are cleaned twice per year. A total of 54,626 lbs of meat consisting of 38,786 lbs of beef products, 14,584 lbs of ham products, 510 lbs of sausage, 350 lbs of franks, 336 lbs of corn dogs, and 60 lbs of buffalo meat, was reportedly purchased between January 1 and November 4, 2000. The fat content of the purchased meats was not available. Figures derived from general fat content information found via internet searches were used for emission calculation purposes (see spreadsheet). For these emissions calculations, it is assumed that 50% of the beef and ham products were cooked by grill and 50% were cooked by broiler. Approximately 300 gallons of food grease are shipped off site for recycling each month. Electrical power is imported from an off site utility. Solid waste is compacted on site and hauled off each week by a Laidlaw Corporation facility located in St. George, Utah. Miscellaneous internal combustion equipment consists of 3 light duty pickups, 2 gasoline-powered trams, a riding lawn mower and a leaf blower. One of the pickup trucks is equipped with a 105-gallon tank that reportedly dispenses 50 gallons per week of unleaded gasoline for this equipment.

For the purposes of calculating seasonal monthly averages (April through October and November through March) percentages of the parks annual visitor counts were established for each month (see Worksheet 1). The percentage for each period was then totaled and averaged. This average percentage was then applied to the annual fuel and meat data for Zion Lodge to develop average monthly usage for each period. Unlike the Park Headquarters and Park Residences, it was felt the greater influence on fuel consumption at the Zion Lodge would likely be monthly park visitation percentages.

Park Headquarters (Old Visitor Center/Future Museum)

Sources of emissions from this location consist of propane combustion for water and space heating and exhaust emissions from a propane fueled backup electricity generator. To better apportion the annual propane usage figure provided for this location to seasonal average monthly values, a heating month approach was utilized (see Worksheet 2). The differences between 65 degrees and the average low temperature for each month were calculated and monthly percentages were subsequently established. These monthly

percentages were then applied to the annual fuel usage data. The totals for April through October and November through March time periods were then averaged for each time period. It was reported that the generator is operated 6-8 hours per year. Propane consumption is assumed to be 2 gallons per hour and was apportioned equally over the entire year.

Park Maintenance Yard

Sources of emissions within the NPS maintenance yard are propane combustion for water and space heating, waste oil combustion for space heating, gasoline and diesel dispensing, parts degreasing, and filling of the gasoline and diesel storage tanks. The heating month calculations were used to apportion the propane and waste oil combustion. Monthly gasoline and diesel consumption figures for August 1999 through July 2000, found in the Park's response to an earlier air quality/emissions survey, were used to determine seasonal average monthly emissions. The reported quantity of degreasing fluid was apportioned equally over the entire year. The same monthly gasoline and diesel consumption figures for August 1999 through July 2000 were used to calculate and apportion evaporative emissions from the filling of the gasoline and diesel storage tanks.

Shuttle Bus Maintenance Yard

The only emissions noted at the shuttle bus maintenance yard are those from refueling the shuttle buses and filling the propane storage tanks. The total usage reported by the concessionaire was adjusted to reflect a full 214 day season (April through October) and emissions were calculated based on factors provided in USEPA report number NR-013, "Refueling Emissions for Nonroad Engine Modeling" (August, 1998).

Watchman Bone Yard

Pile burning of brush and other wood waste is conducted twice a year during the spring and during the fall. From a visual observation by CE-CERT staff, the pile in existence, at that time, was estimated to be 30 feet by 30 feet by 10 feet. Density was further estimated at 20 pounds per cubic foot. It is assumed this pile is representative of the amount of material combusted during each burn.

New **Visitors' Center**

This facility utilizes a combination of line and solar electric power. Cooling during the summer is performed by an energy efficient cooling tower system. No emission sources were reported nor observed at this location.

Environmental Education Center

This building is electrically heated. No emissions sources were reported nor observed at this location.

Kolob Canyon Visitors' Center

This building is electrically heated. No emissions sources were reported nor observed at this location.

The Grotto House

The Grotto House, located along the Zion Canyon road, is a residential building that is now used for meetings on a seasonal basis (April through October). Occasionally, wood is used for facility heating. Reported consumption is 0.25 cords of cottonwood per year.

Oak Creek Residential Area

Within this residential area there are 13 housing units, including a dormitory, located in the vicinity of the NPS maintenance yard. Annual figures for propane and wood use were apportioned based upon the heating month calculation previously described (see Park Headquarters description). Wood type was reported as mixed pinon and juniper. A firewood concessionaire located in Lubbock, Texas, who sells both types of wood, provided estimates of the weight per cord. For purposes of these emission calculations, it was assumed the firewood is comprised of equal volumes of pinon and juniper. The emissions were calculated on the basis of the residential wood stoves being clean burning per the Park's response to an earlier air quality/emissions survey (AP-42 - Post 1990, Non-catalytic).

Watchman Residential Area

Within this residential area there are 15 units located in the vicinity of the south campground. Annual figures for propane and wood use were apportioned based upon the heating month calculation previously described (see Park Headquarters description). Wood type was reported as mixed pinon and juniper. A firewood concessionaire located in Lubbock, Texas, who sells both types of wood, provided estimates of the weight per cord. For purposes of these emission calculations, it was assumed firewood is comprised of equal volumes of pinon and juniper. The emissions were calculated on the basis of the residential wood stoves being clean burning per the Park's response to an earlier air quality/emissions survey.

Kolob Canyon Residence

This is a seasonal residence occupied during the April through October time frame. No propane or wood usage information was collected. It is assumed fuel usage would be the same as that reported for the seasonal residence at Fire Pit.

Pine Creek Superintendent Residential Area

Within this residential area there are three units located between the Park Headquarters and the junction of the Zion Canyon road. Electricity is the primary heating source supplemented with wood combustion. Wood usage is apportioned in accordance with the heating month calculation previously described (see Park Headquarters description).

East Entrance Residential Area

There are two residences at this location. One is a seasonal residence that is occupied during the April through October timeframe and the other is occupied on a year-round basis. The seasonal residence is heated with propane. Electricity is the primary heating source for the other residence, supplemented with wood combustion. Reported propane usage was apportioned over the April through October time period and wood usage was apportioned in accordance with the heating month calculation for the Park.

Lava Point Residence

There is one seasonal residence at this location that is heated with propane. Electricity is reportedly provided by a photovoltaic system at the site. Reported propane usage was apportioned over the April through October time period.

Fire Pit Residence

There is one seasonal residence at this location that is heated with propane. Electricity is reportedly provided by a photovoltaic system at the site. Reported propane usage was apportioned over the April through October time period.

Table 3.1: Emissions from Campgrounds

Campground	N Latitude	W Longitude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Watchman	37°11.770'	112°59.312'	3897	Summer	169	A&B loops	Yes	50.0%	100.0%	Pine	15
	TSP	PM10	VOC	NOX	CO	SOx					
General Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	657.8	657.8	4,353.9	49.4	4,802.6	7.6					
	TSP	PM10	VOC	NOX	CO	SOx					
RV Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
Propane	2.4	2.4	1.8	84	8.4	60					
Generator	0.1	0.1	3.7	0	10.1	0					
Summer Campground	TSP	PM10	VOC	NOX	CO	SOx					
Totals	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	660.3	**660.3**	**4,359.4**	**133.4**	**4,821.1**	**67.6**					

Campground	N Latitude	W Longitude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Watchman	37°11.770'	112°59.312'	3897	Winter	169	A&B loops	Yes	80.0%	40.0%	Pine	15
	TSP	PM10	VOC	NOX	CO	SOx					
General Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	421	421	2,786.50	31.6	3,073.60	4.9					
	TSP	PM10	VOC	NOX	CO	SOx					
RV Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
Propane	0.684	0.684	0.513	23.94	2.39	17.1					
Generator	0	0	0	0	0	0					
Winter Campground	TSP	PM10	VOC	NOX	CO	SOx					
Totals	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	421.7	**421.7**	**2787.0**	**55.6**	**3076.0**	**22.0**					

Table 3.1: Emissions from Campgrounds, (Cont.)

Campground	N Latitude	W Longitude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
South	37°12.172'	112°59.130'	4030	Summer	128	No	Yes	50.0%	100.0%	Pine	15
	TSP	PM10	VOC	NOX	CO	SOx					
General Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	498.2	498.2	3,297.60	37.4	3,637.40	5.8					
	TSP	PM10	VOC	NOX	CO	SOx					
RV Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
Propane	0.0	0.0	0.0	0.0	0.0	0.0					
Generator	0.0	0.0	0.0	0.0	0.0	0.0					
Summer Campground	TSP	PM10	VOC	NOX	CO	SOx					
Totals	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	498.2	**498.2**	**3297.6**	**37.4**	**3637.4**	**5.8**					

Campground	N Latitude	W Longitude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
South	37°12.172'	112°59.130'	4030	Winter	128	No	Yes	80.0%	40.0%	Pine	15
	TSP	PM10	VOC	NOX	CO	SOx					
General Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	318.9	318.9	2110.5	24.0	2328.0	3.7					
	TSP	PM10	VOC	NOX	CO	SOx					
RV Sites	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
Propane	0.0	0.0	0.0	0.0	0.0	0.0					
Generator	0.0	0.0	0.0	0.0	0.0	0.0					
Winter Campground	TSP	PM10	VOC	NOX	CO	SOx					
Totals	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)					
	318.9	**318.9**	**2110.5**	**24.0**	**2328.0**	**3.7**					

Camping Totals

		TSP	PM10	VOC	NOX	CO	SOx
Season:	**Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		1,158.5	**1,158.5**	**7,657.0**	**170.8**	**8,458.5**	**73.4**
		TSP	PM10	VOC	NOX	CO	SOx
Season:	**Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		740.6	**740.6**	**4,897.5**	**79.6**	**5,404.0**	**25.7**

Table 3.2: Emissions from Zion Lodge

Lodge	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Zion Lodge	37°15.113'	112°57.373'	4278	Summer	Oil Boiler	None	2673	Propane	None	**7298**
	TSP	PM10	VOC	NOX	CO	SOx				
Heating Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1	5.3	2.9	0.8	53.5	13.4	384.9				
Unit 2	2.9	2.9	2.2	102.2	**13.9**	73				
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	8.3	**5.9**	**3.0**	**155.6**	**27.2**	**457.9**				

Lodge	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Zion Lodge	37°15.113'	112°57.373'	4278	Winter	Oil Boiler	None	763	Propane	None	2083
	TSP	PM10	VOC	NOX	CO	SOx				
Heating Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1	1.5	0.8	0.2	15.3	3.8	**109.9**				
Unit 2	0.8	0.8	0.6	29.2	4	20.8				
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	2.4	**1.7**	**0.9**	**44.4**	**7.8**	**130.7**				

Table 3.2: Emissions from Zion Lodge (cont.)

Food Preparation		N Latitude	W Longitude	Elevation (ft)	Season	Lowfat Meat Grilled (lbs/month)	Highfat Meat Grilled (lbs/month)	Control	Lowfat Meat Broiled (lbs/month)	Highfat Meat Broiled (lbs/month)	Control
Zion Lodge Rest.		37°15.113'	112°57.373'	4278	Summer	0	4,093.0	Metalbestos Filter	7.0	2,301.0	Metalbestos Filter
		TSP	PM10	VOC	NOX	CO	SOx				
		(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
LwFt Grilled		0.0	0.0	0.0	0.0	0.0	0.0				
HiFt Grilled		20.5	20.5	0.8	0.0	0.0	0.0				
LwFt Broiled		0.0	0.0	0.0	0.0	0.0	0.0				
Hi Ft Broiled		73.6	73.6	8.7	0.0	0.0	0.0				
Food Prep.		TSP	PM10	VOC	NOX	CO	SOx				
Totals	**Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
		94.1	**94.1**	**9.6**	**0.0**	**0.0**	**0.0**				

Food Preparation		N Latitude	W Longitude	Elevation (ft)	Season	Lowfat Meat Grilled (lbs/month)	Highfat Meat Grilled (lbs/month)	Control	Lowfat Meat Broiled (lbs/month)	Highfat Meat Broiled (lbs/month)	Control
Zion Lodge Rest.		37°15.113'	112°57.373'	4278	Winter	0	**1,184.0**	Metalbestos Filter	2.0	657.0	Metalbestos Filter
		TSP	PM10	VOC	NOX	CO	SOx				
		(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
LwFt Grilled		0.0	0.0	0.0	0.0	0.0	0.0				
HiFt Grilled		5.9	5.9	0.2	0.0	0.0	0.0				
LwFt Broiled		0.0	0.0	0.0	0.0	0.0	0.0				
Hi Ft Broiled		21.0	21.0	2.5	0.0	0.0	0.0				
Food Prep.		TSP	PM10	VOC	NOX	CO	SOx				
Totals	**Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
		26.9	**26.9**	**2.7**	**0.0**	**0.0**	**0.0**				

Zion Lodge Totals

		TSP	PM10	VOC	NOX	CO	SOx
Season:	**Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		102.4	**100.0**	**12.6**	**155.6**	**27.2**	**457.9**
		TSP	PM10	VOC	NOX	CO	SOx
Season:	**Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		29.3	**28.6**	**3.6**	**44.4**	**7.8**	**130.7**

Table 3.3: Emissions from Facilities

Facility	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Headquarters/Old Center	37°11.987'	112°59.205'	3925	Summer	PropaneHt	None	266	Prop.Gen.	None	1.3

Energy Unit	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.1	0.1	0.1	3.7	0.5	2.7
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.1	**0.1**	**0.1**	**3.7**	**0.5**	**2.7**

Facility	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Headquarters/Old Center	37°11.987'	112°59.205'	3925	Winter	PropaneHt	None	828	Prop.Gen.	None	1.3

Energy Unit	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.3	0.3	0.2	11.6	1.6	8.3
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.3	**0.3**	**0.2**	**11.6**	**1.6**	**8.3**

Facility	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Maintenance Yard	37°12.678'	112°59.369'	4035	Summer	PropaneHt	None	358	Waste Oil	None	4

Energy Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.1	0.1	0.1	5.0	0.7	3.6
Unit 2	0.0	0.0	0.0	0.0	0.0	0.8

Gasoline Refueled (gal/month)	Control	Gasoline Loaded (gal/month)	Control	Diesel Loaded (gal/month)	Control	Parts Degreasing (gal/month)	Control
3602	None	3602	None	837	None	0.58	WaterBase

Evaporation	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Gasoline Ref.	n/a	n/a	45.7	n/a	n/a	n/a
Gasoline Load.	n/a	n/a	41.4	n/a	n/a	n/a
Diesel Load.	n/a	n/a	0.0	n/a	n/a	n/a
Parts Degreas.	n/a	n/a	0.0	n/a	n/a	n/a
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.1	**0.1**	**87.3**	**5**	**0.7**	**4.4**

Facility	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Maintenance Yard	37°12.678'	112°59.369'	4035	Winter	PropaneHt	None	**117**	Waste Oil	None	14

Energy Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	1.6	0.2	1.2
Unit 2	0.1	0.1	0.0	0.2	0.0	2.8

Gasoline Refueled (gal/month)	Control	Gasoline Loaded (gal/month)	Control	Diesel Loaded (gal/month)	Control	Parts Degreasing (gal/month)	Control
2158	None	2158	None	815	None	0.58	WaterBase

Evaporation	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Gasoline Ref.	n/a	n/a	27.4	n/a	n/a	n/a
Gasoline Load.	n/a	n/a	24.8	n/a	n/a	n/a
Diesel Load.	n/a	n/a	0.0	n/a	n/a	n/a
Parts Degreas.	n/a	n/a	0.0	n/a	n/a	n/a
Totals Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.1	**0.1**	**52.3**	**1.8**	**0.2**	**4**

Table 3.3: Emissions from Facilities (cont.)

Facility		N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Watchman Bone Yard		37°11.678'	112°59.076'	3985	Summer	none	none	none	none	none	none
Energy Units		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
Unit 1		0.0	0.0	0.0	0.0	0.0	0.0				
Unit 2		0.0	0.0	0.0	0.0	0.0	0.0				
Burn Pile (tons/month)	Materials										
10	Misc. trimmings										
Activity		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
Burn Pile		346.0	346.0	2290.0	26.0	2526.0	4.0				
Totals	**Summer**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
		346.0	**346.0**	**2290.0**	**26.0**	**2526.0**	**4.0**				

Facility		N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Watchman Bone Yard		37°11.678'	112°59.076'	3985	Winter	none	none	none	none	none	none
Energy Units		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
Unit 1		0.0	0.0	0.0	0.0	0.0	0.0				
Unit 2		0.0	0.0	0.0	0.0	0.0	0.0				
Burn Pile (tons/month)	Materials										
14	Misc. trimmings										
Activity		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
Burn Pile		484.4	484.4	3206.0	36.4	3536.4	5.6				
Totals	Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
		484.4	**484.4**	**3206.0**	**36.4**	**3536.4**	**5.6**				

Table 3.3: Emissions from Facilities, Cont.

Facility		N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Shuttle Bus Maintenance		n/a	n/a	n/a	Summer	none	none	none	none	none	none
		TSP	PM10	VOC	NOX	CO	SOx				
Heating Units		(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1		0.0	0.0	0.0	0.0	0.0	0.0				
Unit 2		0.0	0.0	0.0	0.0	0.0	0.0				
Propan Refueled (gal/month)	Control	Propane Loaded (gal/month)	Control								
21,171.0	None	21,171.0	None								
		TSP	PM10	VOC	NOX	CO	SOx				
Evaporation		(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Prop. Bus Ref.		n/a	n/a	140.0	n/a	n/a	n/a				
Prop.Tank Load.		n/a	n/a	793.5	n/a	n/a	n/a				
		TSP	PM10	VOC	NOX	CO	SOx				
Totals	**Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
		0.0	**0.0**	**933.5**	**0.0**	**0.0**	**0.0**				

Facility		N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)
Shuttle Bus Maintenance		n/a	n/a	n/a	Winter	none	none	none	none	none	none
		TSP	PM10	VOC	NOX	CO	SOx				
Heating Units		(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1		0.0	0.0	0.0	0.0	0.0	0.0				
Unit 2		0.0	0.0	0.0	0.0	0.0	0.0				
Propan Refueled (gal/month)	Control	Propane Loaded (gal/month)	Control								
0.0	None	0.0	None								
		TSP	PM10	VOC	NOX	CO	SOx				
Evaporation		(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Prop. Bus Ref.		n/a	n/a	0.0	n/a	n/a	n/a				
Prop.Tank Load.		n/a	n/a	0.0	n/a	n/a	n/a				
		TSP	PM10	VOC	NOX	CO	SOx				
Totals	**Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
		0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**				

Table 3.3: Emissions from Facilities, Cont.

Facility	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Wood Used (tons/mo)	Energy Unit 2	Control	Fuel Use (gal/month)
Grotto House	37°15.547'	112°57.081'	4533	Summer	Wood Stove	New	0.04	none	none	none

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	1.2	1.2	2.1	0.1	9.2	0.0
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals **Summer**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	1.2	**1.2**	**2.1**	**0.1**	**9.2**	0

Facility	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Wood Used (tons/mo)	Energy Unit 2	Control	Fuel Use (gal/month)
Grotto House	37°15.547'	112°57.081'	4533	Winter	Wood Stove	New	0	none	none	none

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.0	0.0	0.0
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals **Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Visitor Center

No significant emissions included other than surface coating which is included elsewhere.

Environmental Education Center

No significant emissions included other than surface coating, which is included elsewhere.

Kolob Canyon Visitor Center

No significant emissions included other than surface coating, which is included elsewhere.

East Entrace Station/South Entrance Fee Station/New Walk -In (across river)/Watchman Campground

No significant emissions other than surface coating, which is included elsewhere.

Rockville Sewage Treatment Plant

Treatment plant is outside of the park. Thus park becomes an indirect emission source.

Park Landfill

10 dumpsters taken weekly. Facility is outside of park. Thus park becomes an indirect emission source.

Totals for Facilities

Season	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Summer	**347.5**	**347.5**	**3313.0**	**34.9**	**2536.4**	**11.0**
Winter	**484.9**	**484.9**	**3258.6**	**49.8**	**3538.2**	**17.9**

Table 3.4: Emissions from Residential Units

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Oak Creek Housing	37°12.692'	112°59.365'	4035	Summer	Propane Ht.	None	132	Wood Stove	New	0.6
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1	0.1	0.1	0.0	1.8	0.3	1.3				
Unit 2	18.4	18.4	31.8	1.7	138.6	0.2				
	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	18.4	**18.4**	**31.8**	**3.5**	**138.9**	**1.6**				

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Oak Creek Housing	37°12.692'	112°59.365'	4035	Winter	Propane Ht.	None	415	Wood Stove	New	1.9
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1	0.2	0.2	0.1	5.8	0.8	4.2				
Unit 2	58.1	58.1	100.7	5.3	438.9	0.8				
	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	58.3	**58.3**	**100.8**	**11.1**	**439.7**	**4.9**				

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Watchman Housing	37°12.222'	112°58.782'	4013	Summer	Propane Ht.	None	165	Wood Stove	New	0.5
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1	0.1	0.1	0.0	2.3	0.3	1.7				
Unit 2	15.3	15.3	26.5	1.4	115.5	0.2				
	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	15.4	**15.4**	**26.5**	**3.7**	**115.8**	**1.9**				

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Watchman Housing	37°12.222'	112°58.782'	4013	Winter	Propane Ht.	None	518	Wood Stove	New	1.6
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
Unit 1	0.2	0.2	0.2	7.3	1.0	5.2				
Unit 2	49.0	49.0	**84.8**	4.5	369.6	0.6				
	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	49.2	**49.2**	**85.0**	**11.7**	**370.6**	**5.8**				

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Kolob Canyon				Summer	Propane Ht.	None	20	Wood Stove	New	0.04
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	0.008	0.008	0.0	0.3	0.0	0.2				
	1.2	1.2	2.1	0.1	9.2	0.0				
	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	1.2	**1.2**	**2.1**	**0.4**	**9.3**	**0.2**				

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Kolob Canyon				Winter	Propane Ht.	None	0	Wood Stove	New	0
Heating	TSP	PM10	VOC	NOX	CO	SOx				
Units	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	0.0	0.0	0.0	0.0	0.0	0.0				
	0.0	0.0	0.0	0.0	0.0	0.0				
	TSP	PM10	VOC	NOX	CO	SOx				
Totals **Winter**	**(lbs/month)**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)				
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**				

Table 3.4: Emissions from Residential Units, Cont.

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Pine Creek Superintendent				Summer	Electric Ht	None	0	Wood Stove	New	0.2

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.0	0.0	0.0
Unit 2	6.1	6.1	10.6	0.6	46.2	0.1
Totals **Summer**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	6.1	**6.1**	**10.6**	**0.6**	**46.2**	**0.1**

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Pine Creek Superintendent				Winter	Electric Ht	None	0	Wood Stove	New	0.6

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.0	0.0	0.0
Unit 2	18.4	18.4	31.8	1.7	138.6	0.2
Totals **Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	18.4	**18.4**	**31.8**	**1.7**	**138.6**	**0.2**

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
East Entrance Housing				Summer	Propane Ht.	None	17	Wood Stove	New	0.2

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.2	0.0	0.2
Unit 2	6.1	6.1	10.6	0.6	46.2	0.1
Totals **Summer**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	6.1	**6.1**	**10.6**	**0.8**	**46.2**	**0.3**

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
East Entrance Housing	0.000	0.000	0	Winter	Propane Ht.	None	0	Wood Stove	New	0.8

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.0	0.0	0.0
Unit 2	24.5	24.5	42.4	2.2	184.8	0.3
Totals **Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	24.5	**24.5**	**42.4**	**2.2**	**184.8**	**0.3**

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Lava Point Housing (1 unit)				Summer	Propane Ht.	None	1.9	Wood Stove	New	0

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.0	0.0	0.0
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals **Summer**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Lava Point Housing (1 unit)				Winter	Propane Ht.	None	0	Wood Stove	New	0

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.0	0.0	0.0
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals **Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Table 3.4: Emissions from Residential Units, Cont.

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Firepit (1 **unit)**				Summer	Propane Ht	None	20			

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.3	0.0	0.2
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals **Summer**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.0**	**0.3**	**0.0**	**0.2**

Residential Area	N Latitude	W Longitude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)
Firepit (1 **unit)**	0.000	0.000	0	Winter	Propane Ht	None	0			

Heating Units	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Unit 1	0.0	0.0	0.0	0.0	0.0	0.0
Unit 2	0.0	0.0	0.0	0.0	0.0	0.0
Totals **Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Totals for Residential

Season **Summer**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	47.2	**47.2**	**81.6**	**9.3**	**356.4**	**4.3**

Season **Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	150.4	**484.9**	**3258.6**	**49.8**	**3538.2**	**17.9**

Chapter Four - Area Sources

Miscellaneous Solvent Usage

MSDS sheets on the materials used within the Park and usage quantities provided by Park personnel were used to calculate the VOC emissions. These emissions were then apportioned equally throughout the year.

Road Maintenance

Approximately 2 miles of road is chip sealed each year using a reported 1000 tons of hot mix asphalt. Emissions of volatile organics from the asphalt were calculated using AP-42 emission factors and apportioned equally over the entire year.

Cinder Storage Piles

Cinders used for road maintenance are stored in open piles in an area between the visitor center parking lot and the Watchman residential area. An estimate of the size of the cinder piles was made at the time of the November on-site visit. A moisture content of 3% was assumed along with an average wind speed of 3 mph. The AP-42 emission factor for crushed limestone was used in order to best approximate the emissions.

Prescribed Burning

The reported annual average acreage of prescribed burns was seasonalized on the assumption that 70% of the burning occurred during the November through March time period. The fuel consumption rate was based on the average of the recorded rates of previous prescribed burns conducted within the Park. The AP-42 average emission factor for the Pacific Southwest region was used to estimate the pollutant emissions.

Some prescribed burning also is conducted in drainage ditches around the camping areas. It was assumed all of this burning would occur during the November to March timeframe. A fuel consumption rate of 2 tons per acre was assumed. The AP-42 emission factor for grassland burning was used to estimate the pollutant emissions.

Wildfires

Park Personnel provided an annual average of the acreage consumed by wildfires. It was assumed that all of these fires occur during the April through October time period. The fuel consumption was taken from the AP-42 handbook for the Intermountain region. The AP-42 emission factors for wildfires were used to estimate the pollutant emissions.

Re-entrained Road Dust, Tire & Brake Wear

Monthly vehicle counts from the Monthly Public Use Report (form 10-157) and the average distances traveled per vehicle, provided in the Park's response to the earlier air

quality/emissions survey, were used to develop monthly mileage figures by season for travel on paved roads within the Park. Emission factors were developed from the Part5 model and AP-42.

There are ten unpaved road sections within the Park's boundaries which total 14.02 miles in length: Cave Valley-1.27, Cornelius Inholding-0.71, Firepit Knoll-1.50, Horse Ranch Mt-0.94, Kolob VC-0.37, Lava Point/MIA Camp-4.92, Lee Inholding-1.92, Lee Valley-0.83, Oak Creek Rd-0.62, Smith Mesa-0.93. There is no direct information available on the number of vehicles using any of these road sections or the miles traveled. However, with some assumptions, it is possible to develop estimates for the two-road sections: Lava Point/MIA Camp and Kolob VC.

The entire 9.95 miles of the Kolob Terrace road that is inside the Park must be traveled in order to access the gravel road to Lava Point/MIA Camp. In the earlier response to the air quality/emissions survey, Park personnel estimated 50% of the traffic on the Kolob Terrace road was by local residents. It would appear unlikely that local residents would constitute a significant portion of the visitors to the Lava Point/MIA Camp. Thus, the number of vehicles traveling to Lava Point/MIA Camp can be expected to be less than 50% of the total vehicle count recorded for Kolob Terrace. The earlier response by Park personnel provided an estimate that the average vehicle travels 66% of the in-park section of Kolob Terrace road. (However, in that response it appears the resultant value failed to recognize the return leg of the trip. Thus, the average visitor trip on Kolob Terrace Road would be 9.95 x .66 x 2 or 13.1 miles.) For this emissions inventory, it is assumed that 50% of the Park visitors that drove on the Kolob Terrace Road also traveled to Lava Point. The length of the gravel road within the Park boundary that is traveled to access Lava Point was not reported. However, the entire distance to the MIA Camp was reported and, used in combination with a map of the park, allows an estimate of 1 mile. It is further assumed that 10% of the visitors that travel to Lava Point during the April through October time period also travel the MIA Camp road. For the November through March time period that estimate is lowered to 5%. At the time of the CE-CERT visit in August 2000, the road to Lava Point/MIA Camp was noted to be heavily wash-boarded. As a result, vehicle speeds on the road are expected to be 20 MPH or less.

As noted earlier, there is one seasonal residence near the Kolob Canyon Visitors' Center. It is accessed by a gravel road reported as 0.37 miles in length. It is estimated that road section is traveled an average of 5 times per day during the April through October time period by the seasonal residents. The AP-42 emission factor for rural roads was used to estimate emissions.

Table 4.1: Emissions from Solvent Usage

Miscellaneous Solvent Usage

Name of Material	Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
Summer				
Acrylic Latex Paint	145	1.29	8.3%	10.9
Mineral Spirits	2	0.83	72.0%	0.8
Gasoline	1	0.72	100.0%	0.5
Sundance Pipeline #4 Neutral Floor Cleaner	50	1.03	30.0%	10.9
Command Center 2 LOOK Glass Cleaner Concentrate	3	0.99	93.0%	1.9
Command Center 22 Speedball 2000 Power Cleaner Conc.	3	1	80.0%	1.7
Blue Skies Disinfectant Cleaner	2	1.01	88.0%	1.2
Command Center 19 Triple Team heavy Duty Washroom Cleaner	1.5	1.05	56.0%	0.6
Simple Green	7	1.0257	0.8%	0.0
Zeptox	0.6	0.795	100.0%	0.3
Total **Summer**				**29.0**

Name of Material	Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
Winter				
Acrylic Latex Paint	145	1.29	8.3%	10.9
Mineral Spirits	2	0.83	72.0%	0.8
Gasoline	1	0.72	100.0%	0.5
Sundance Pipeline #4 Neutral Floor Cleaner	50	1.03	30.0%	10.9
Command Center 2 LOOK Glass Cleaner Concentrate	3	0.99	93.0%	1.9
Command Center 22 Speedball 2000 Power Cleaner Conc.	3	1	80.0%	1.7
Blue Skies Disinfectant Cleaner	2	1.01	88.0%	1.2
Command Center 19 Triple Team heavy Duty Washroom Cleaner	1.5	1.05	56.0%	0.6
Simple Green	7	1.0257	0.8%	0.0
Zeptox	0.6	0.795	100.0%	0.3
Total **Winter**				**29.0**

Table 4.2: Emissions from Road Paving

Road Maintenance

Name of Material	Amount (tons/month)	VOC Factor	VOC (lbs/month)
Summer			
Asphalt Paving	83.3	0.2	33,320.0
Total Summer			**33,320.0**
Name of Material	**Amount (gals/year)**	VOC Factor	VOC (lbs/month)
Winter			
Asphalt Paving	83.3	0.2	33,320.0
Total Winter			**33,320.0**

Total Evaporative Emissions

	VOC (lbs/month)
Summer	**33,349.0**
Winter	**33,349.0**

Table 4.3: Emissions from Other Area Sources

Item	N Latitude	W Longditude	Elevation (ft)	Season	Pile Surface Area (sqft)	Number of Piles
Cinder Piles	37°12.106'	112°58.957'	3856	Summer	100	3
	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Cinder Piles	0.7	0.4	n/a	n/a	n/a	n/a
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.7	**0.4**	**n/a**	**n/a**	**n/a**	**n/a**

Item	N Latitude	W Longditude	Elevation (ft)	Season	Pile Surface Area (sqft)	Number of Piles
Cinder Piles	37°12.106'	112°58.957'	3856	Winter	100	3
	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Cinder Piles	0.7	0.4	n/a	n/a	n/a	n/a
Totals Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.7	**0.4**	**n/a**	**n/a**	**n/a**	**n/a**

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month	Type Burning	Tons/Acre Burned	Acres Burned per Month
Prescribed Burning				Summer	Grass/Brush	2	0	General	10.5	29
	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
	0.0	0.0	0.0	0.0	0.0	0.0				
	10840.2	7917.0	3684.5	1218.0	42630.0	30.5				
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
	10840.2	**7917.0**	**3684.5**	**1218.0**	**42630.0**	**30.5**				

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month	Type Burning	Tons/Acre Burned	Acres Burned per Month
Prescribed Burning				Winter	Grass/Brush	2	4	General	10.5	100
	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
	160.0	160.0	55.2	32.0	1200.0	0.8				
	37380.0	27300.0	12705.0	4200.0	147000.0	105.0				
Totals Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)				
	37540.0	**27460.0**	**12760.2**	**4232.0**	**148200.0**	**105.8**				

Table 4.3: Emissions from Other Area Sources (cont.)

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month
Wildfires				Summer	General	18	114

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
General	34884.0	24418.8	26060.4	8208.0	287280.0	205.2
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	34884.0	**24418.8**	**26060.4**	**8208.0**	**287280.0**	**205.2**

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month
Wildfires	0.000	0.000	0	Winter	General	18	0

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
General	0.0	0.0	0.0	0.0	0.0	0.0
Totals Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Item	N Latitude	W Longditude	Elevation (ft)	Season	Miles of Paved Road	Miles Driven on Paved per Month	Miles of Unpaved Road	Miles Driven on Unpaved per Month
Reintrained Road Dust				Summer	39.7	992,224	14	104.0

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Paved Roads	14,861.5	3,016.0	n/a	n/a	n/a	n/a
Unpaved Roads	178.4	64.1	n/a	n/a	n/a	n/a
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	15,040.0	**3,080.2**	n/a	n/a	n/a	n/a

Item	N Latitude	W Longditude	Elevation (ft)	Season	Miles of Paved Road	Miles Driven on Paved per Month	Miles of Unpaved Road	Miles Driven on Unpaved per Month
Reintrained Road Dust				Winter	39.7	646,672	14	30.0

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Paved Roads	**9,685.8**	1,965.7	n/a	n/a	n/a	n/a
Unpaved Roads	48.3	11.2	n/a	n/a	n/a	n/a
Totals Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	9,734.1	**1,976.9**	**n/a**	**n/a**	**n/a**	**n/a**

Total Piles and General Fires

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Season: Summer	**60,764.9**	**35,416.4**	**29744.9**	**9,426.0**	**329,910.0**	**235.7**
Season: Winter	**47,274.8**	**29,437.3**	**12,760.2**	**4,232.0**	**148,200.0**	**105.8**

Chapter Five - Mobile Sources

The estimation of mobile source emissions represents the most complex data gathering and data analyses of this entire inventory. As described below in significant detail, it was necessary to first determine the composition of the in-Park vehicle fleet, and the driving patterns of vehicles operating within the Park. This information was then used as input in EPA's Mobile 5b model to develop emission factors applicable to Zion National Park. These factors were then used in conjunction with the records of the number of vehicles entering the Park to determine the total emissions (both evaporative and exhaust) generated by mobile sources operating within the Park.

Need for Characterization of the In-Park Vehicle Fleet

Use of the standard inputs for emission modeling of mobile sources within a National Park may be inaccurate in two main areas: the vehicle fleet and the driving behavior. Large differences in emissions rates have been observed across model years in an in-use vehicle fleet, resulting from the large reductions in emissions with improvements in emission control technology. [Calvert, et. al., 1993] Improvements in fuel control and catalyst technology, particularly with the advent of the Tier 1 emissions standards starting in 1994, have resulted in far lower emissions from typical vehicles. Accurate characterization of the vehicle fleet is essential for proper estimation of emissions because of these large differences in emission rates.

Need for Characterization of In-Park Driving Patterns

Driving behavior can also have a large influence on emissions of vehicles, particularly with newer vehicles because of command enrichment of the air/fuel mixture. Emissions can vary by an order of magnitude within the space of a few seconds, with the response frequently non-linear because of enrichment or enleanment of the air-fuel mixture. Enrichment occurs in modern computer-controlled vehicles based on proprietary engine control strategies. The computer enriches the air-fuel mixture at high power to protect the catalytic converter from heat damage, resulting in short-term spikes in emissions. The size and timing of the emissions increases vary from vehicle to vehicle, even for identical models. Enleanment occurs in some modern computer-controlled vehicles during coast down and braking events. The various factors present in the national parks that may influence mobile source emissions are summarized in Table 5.1.

Table 5.1 Summary of Factors That Have the Potential to Influence Mobile Source Emissions in National Parks

Factor	Expected Result
Vehicle Distribution – Higher Proportion of New Vehicles	Lower Emissions
Vehicle Distribution – Higher Proportion of Trucks and *SUV's*	Higher Emissions
Vehicle Driving Patterns – Absence of High Speed (> 50 mph) Driving	Lower Emissions
Vehicle Driving Patterns – Lower Average Speed	Potential for Lower or Higher Emissions
Vehicle Driving Patterns – Milder Accelerations/Decelerations	Lower Emissions
Vehicle Load – Higher Proportion of Vehicles Having Trailers	Higher Emissions
Vehicle Load – Higher Road Grade Than Typical Driving	Higher Emissions

Description of Evaporative and Tailpipe Emissions

Pollution from vehicles is typically broken into two components denoted evaporative emissions and tailpipe emissions. Evaporative emissions involve emissions of volatile organic compounds (VOC) resulting from the evaporation of gasoline and diesel fuel from parked and moving vehicles. Evaporative emissions also occur when vehicles are being refueled, but for purposes of this study, these emissions will be considered to be stationary source emissions and will be treated in a different section of the report. It should be noted that the evaporation of diesel fuel is very small and is thus typically ignored. Tailpipe emissions are of course associated with the combustion of fuel in the engine and consist primarily of VOC, NOx, SOx, CO, and PM2.5.

Evaporative emissions are dependent upon the volatility of the fuel involved, the ambient temperature that the fuel is subjected to and the nature of any onboard control that exists on vehicles. Newer vehicles have more elaborate and of course newer control systems that typically function better to prevent evaporative emissions. It has more recently been found that small seeps can occur in fuel line hoses and connections that can be undetectable by vehicle owners and automotive maintenance personnel but can represent substantial additional evaporative emissions. Steps have been taken in the manufacture of newer vehicles to eliminate these seeps by using improved materials and connectors. Again, the age distribution of the fleet of vehicles being analyzed combined with the ambient temperature is the key determinate of the amount of evaporative emissions from vehicles.

Most tailpipe emissions, with the exception of nitrogen oxides, are the result of the incomplete combustion of fuels in vehicle engines. Nitrogen oxides result from the high temperatures that occur in engine cylinders and tend to be produced at maximum quantity when an engine is running under optimum power conditions. The actual emissions from an engine at a point in time depend upon the amount of fuel injected into the engine cylinders combined with the air to fuel ratio and the pressures in the cylinders. These emissions are further exacerbated by leaks around valves and pistons and reduced by

control equipment in the exhaust stream. The amount of fuel injected into the engine cylinders is a function of the power demand on the engine. Thus, emissions from vehicles are continuously changing as a vehicle is taken through various load situations by the driver and vary from vehicle to vehicle depending upon engine design and age, exhaust treatment, terrain and altitude.

In order to deal with the complexities of evaporative and tailpipe emissions, the U.S. EPA and the California Air Resources Board along with other private and public laboratories have carried out considerable in-use vehicle testing under various driving conditions and ages. Using these data, three important vehicle emissions models have been developed for use in air pollution control planning. The U.S. EPA produces a model designated as the "MOBILE" model to estimate VOC, NOx, and CO and the "Part5" model to estimate particulate matter from vehicles. The California Air Resources Board produces a model denoted "EMFAC," which is designed specifically for California and estimates VOC, NOx, CO, and particulate matter. These models have undergone many revisions to try and improve their accuracy. The latest version of MOBILE is MOBILE5b; although, a version 6 has been promised within the next few months. The latest version of the particulate model is Part5. The U.S. EPA has indicated that they intend to include particulate estimates in Mobile 6 in 2001. The latest version of the California model is EMFAC2000, which is still in the beta testing mode.

All of these models are focused on estimating emissions in urban non-attainment areas where the greatest air quality problems have traditionally occurred. They are based on specific driving patterns selected to be typical of modern urban driving. These models include emission adjustments based on average vehicle speed, which have been developed through subsequent urban testing. These emission estimates and speed corrections are questionable when applied to driving situations that may not be typical of general urban driving. To address the limitations in the MOBILE and EMFAC models for analysis of specific highway situations or non-urban areas with differing patterns, or modes, of driving, several modal models have been developed. In late 1995, the Bourns College of Engineering, Center for Environmental Research and Technology (CE-CERT) at the University of California, Riverside undertook a cooperative investigation with the University of Michigan and Lawrence Berkeley National Laboratory in order to develop a comprehensive modal emissions model (CMEM). CMEM provides an alternate means for estimating vehicle emissions for situations where non-standard driving patterns may be the norm. [Barth et al. (1996), Barth et al. (1997), and An et al. (1997).] CMEM and all of the other presently available modal models are relatively new and have not received the full range of review accorded the MOBILE, Part5, and EMFAC models. However, as part of the model development process, CMEM was given a full validation, including a bootstrap analysis of the model bias on a second-by-second basis for independent test cycles. [Schulz et al, 2000.] CMEM is based on specific measurements conducted on about 400 in-use vehicles where specific driving patterns were established to facilitate modal model development. The resulting CMEM model has been demonstrated to provide accurate emission estimates for normally operating vehicles driven under a wide range of EPA facility cycles and for some types of malfunctioning vehicles. [Levine et al, 2000]

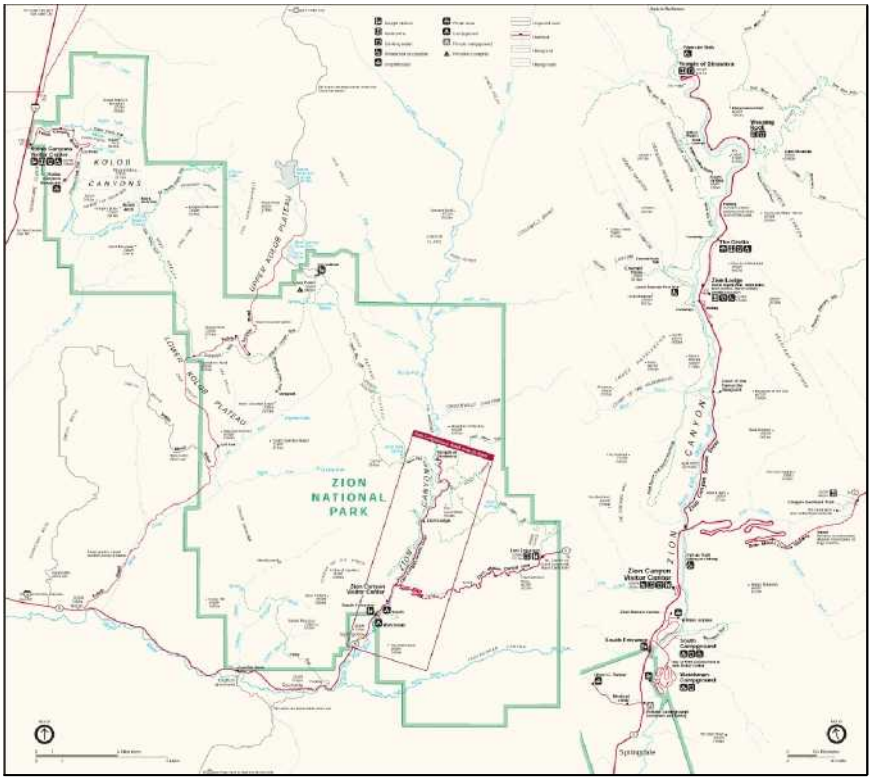
The approach selected to estimate emissions from vehicles in this study is to use the latest available versions of the MOBILE and PART5 models as the core emissions models. Adjustments will then be made to these model results based on additional analysis provided by the CMEM model as described in succeeding sections. If large differences in driving behavior are found between the FTP driving cycle and driving within the Park the CMEM adjustments will be of greater importance because MOBLE5b corrects for differences in average speed, but has no means for correcting for differences in accelerations and decelerations.

Data Collection Methodologies

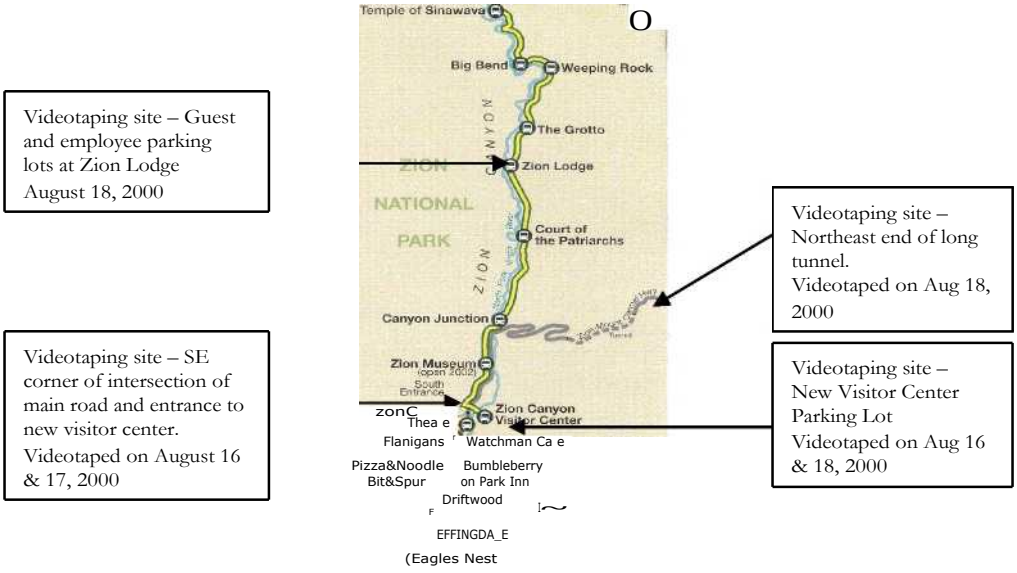
As noted in the introduction, an important component in estimating vehicle emissions is the type of vehicles operating in the analysis region. The EPA and most State governments provide vehicle distribution data on a national, state, or county level. It was felt, however, that the distribution of vehicles in national parks would not normally follow these national or state default distributions. Vehicles arrive at national parks from many states with some bias toward the state in which the park is located, and it was expected that park visitors will tend to use their most modern and comfortable vehicles to travel to and through national parks thus skewing the vehicle distribution from the default values selected to be typical of urban areas. Thus, a key element of this study is to analyze the vehicle fleet presently operating in the national parks of interest.

To determine the vehicle distribution in Zion National Park, a digital video camera was set up at two locations in the Park in order to photograph a representative sample of the vehicles traveling within the Park. (See Maps 5.1a & 5.1b) In addition, all vehicles in the visitor center parking lot at Zion National Park were videotaped on three different occasions. Approximately 6 hours of videotaping was conducted and some 2,000 vehicles were recorded. These vehicles were subsequently identified and classified according to their vehicle type and age.

Map 5.1a: Vehicle Video Locations in Zion National Park



Map 5.1b: Video Locations in Zion National Park



A second critical link in estimating vehicle emissions is the driving patterns and resulting loads that vehicles are subjected to during operations. These driving patterns potentially consist of a cold start inside of or outside of the park, driving in the park with potentially

frequent stops and subsequent warm starts of the vehicle. Driving behavior has a large effect on emissions of motor vehicles, with emissions of newer vehicles increasing by a factor of 10 to 100 during enrichment events. The lower posted speed limits in the national parks, combined with the frequent stops for sightseeing are expected to have an influence on the driving patterns in the parks. The relative proportion of hard accelerations and decelerations in national park driving in comparison with "typical" driving represented in the standard emission models has the potential to significantly increase or decrease the estimated emissions within the parks. During the planning phase of this project it was envisioned that driving patterns within National Parks are significantly different from the typical urban driving simulated in the conventional U.S. EPA and California models. For this reason, CE-CERT employed data collection methodologies in order to construct and compare in-park driving patterns with the typical urban driving patterns used in these conventional models.

Driving pattern data was collected using an instrumented 1997 Ford Expedition. The data collection was accomplished by selecting random Park visitors for following during their Park visit. The chase car driver manually matched the speed of the target vehicles and care was taken to stay far enough from the followed vehicle to not disturb the driver's normal vehicle driving pattern. The driving data collected is not an exact match to the target vehicle because of small errors introduced by the chase car driver, however the slow speeds and moderate accelerations of vehicles within the park provide optimal conditions for this type of data collection. The primary data collection was accomplished using a Garmin Differential GPS unit mounted in the vehicle and connected to a laptop computer, with backup provided through a second laptop linked to the On-Board Diagnostic (OBD) system of the chase car, which also recorded vehicle speed. In the event that satellite signals to the GPS unit were interrupted while driving in narrow canyons or through tunnels, the OBD monitoring system would continue to provide the vehicle speed and a means to determine the engine load.

Data from the GPS unit was transmitted at 2-second intervals. This data included time, vehicle speed, location, and altitude. These data were imported into Excel files for each vehicle followed and then analyzed. Because of the sheer volume of the GPS data it will be made available electronically upon request.

In-Park Vehicle Fleet Results

The vehicle data collected from the videotapes at Zion National Park was used to create a fleet distribution representative of the in-park vehicle fleet. For purposes of this study, it was found necessary to combine the in-park vehicle distribution data also collected in Arches National Park in August 2000 with that of the Zion National Park vehicle data. Combining the data was necessary because of the small percentage of vehicles in the diesel categories. Small proportions of these vehicles make estimation of their true percentages difficult without large amounts of data.

The vehicles were categorized into 7 classes used in the MOBILE model (Table 5.2). Most of the recreational vehicles were classed in the LDGT2 or the HDGV category,

depending on size. Table 5.3 displays the national default fleet distribution and the results of the Park-derived fleet distribution. This national fleet distribution is also used by the State of Utah to prepare their emissions inventory. As expected, the fraction of light duty vehicles, heavy light duty trucks (LDGT2) and motorcycles was higher in the Parks, and the fraction of heavy-duty diesel vehicles was lower.

Table 5.2 Vehicle Class Definitions

Vehicle Class	Abbreviation	GVWR
Light Duty Gasoline Vehicle	LDGV	
Light Duty Gasoline Trucks 1	LDGT1	Up to 6000 lbs
Light Duty Gasoline Trucks 2	LDGT2	6001-8500 lbs
Heavy Duty Gasoline Vehicles	HDGV	Greater than 8500 lbs
Light Duty Diesel Vehicles	LDDV	
Light Duty Diesel Trucks	LDDT	Up to 8500 lbs
Heavy Duty Diesel Vehicles	HDDV	Greater than 8500 lbs
Motorcycles	MC	

Table 5.3 Vehicle Distribution Measured in Utah National Parks Compared to National Default Values

Vehicle Type	Default	Parks
LDGV	0.616	0.701
LDGT1	0.191	0.137
LDGT2	0.086	0.106
HDGV	0.031	0.008
LDDV	0.002	0.000
LDDT	0.001	0.003
HDDV	0.068	0.016
MC	0.006	0.028
Total	1.00	1.00

In addition, the approximate age of the vehicle was recorded and a model year distribution for each vehicle class was devised. Due to the difficulty in identifying the exact year of manufacture of each vehicle, the vehicles were grouped into three to four year groupings and attributed equally to the ages in each groups. Table 5.4 compares the Park's distribution to the MOBILE5b default age distribution. As expected, a larger fraction of newer vehicles is present in the Parks data set.

Table 5.4 -Vehicle Age Distribution Measured in Utah National Parks Compared to National Default Values

	LDV		LDT	
Age	Default	Parks	Default	Parks
0	0.049	0.158	0.063	0.161
1	0.079	0.158	0.084	0.161
2	0.083	0.158	0.084	0.161
3	0.082	0.158	0.084	0.161
4	0.084	0.059	0.084	0.043
5	0.081	0.059	0.069	0.043
6	0.077	0.059	0.059	0.043
7	0.056	0.059	0.044	0.043
8	0.050	0.025	0.036	0.025
9	0.051	0.025	0.031	0.025
10	0.050	0.025	0.030	0.025
11	0.054	0.010	0.052	0.018
12	0.047	0.010	0.046	0.018
13	0.038	0.010	0.046	0.018
14	0.024	0.004	0.036	0.010
15	0.019	0.004	0.028	0.010
16	0.014	0.004	0.017	0.010
17	0.015	0.004	0.022	0.010
18	0.011	0.002	0.017	0.004
19	0.008	0.002	0.014	0.004
20	0.006	0.002	0.009	0.004
21	0.005	0.000	0.008	0.001
22	0.004	0.000	0.008	0.001
23	0.003	0.000	0.005	0.001
24	0.010	0.000	0.024	0.000
Total	1.00	1.00	1.00	1.00

In-Park Driving Pattern Results

Nineteen vehicles were followed at the Zion National Park. The speed/acceleration events were grouped and plotted. These summations are illustrated in Figure 5.1. The vertical scale is the fraction of time spent at a given speed/acceleration event. As can be seen, the primary speed/acceleration event is at a speed of 18 to 22 miles per hour with little acceleration (i.e., constant speed). The second of the two graphs is a plan (overhead) view of the first. The area above the vertical centerline represents accelerations and that below the centerline represents decelerations. As can be seen, accelerations varied typically between ±2 miles per hour/second.

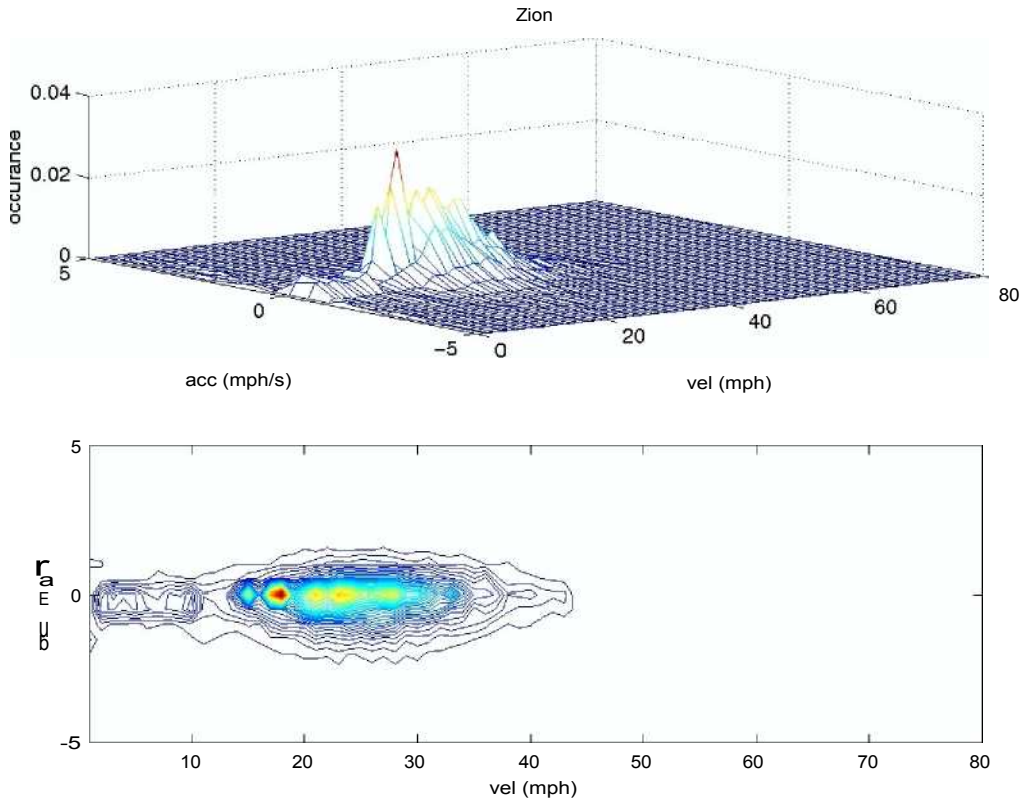


Figure 5.1 - Driving Patterns of Nineteen Vehicles Followed at Zion National Park

Comparison With Federal Test Procedure (FTP)

The traditional driving pattern used for the development of emission factors for both Mobile and EMFAC is the Federal Test Procedure (FTP). This driving pattern was first designed in the 1970s. In recent years this driving pattern has been criticized for not being representative of modern driving patterns, which typically have higher speeds and harder accelerations. A new pattern, the US06, is in use as a supplement to the FTP. This driving pattern contains more hard accelerations and higher speeds compared to the FTP increasing predicted urban emissions. For comparison purposes, the FTP was used since it is still the primarily used driving pattern. Figure 5.2 breaks the FTP driving cycle into speed/acceleration events to compare with the data collected in Zion National Park.

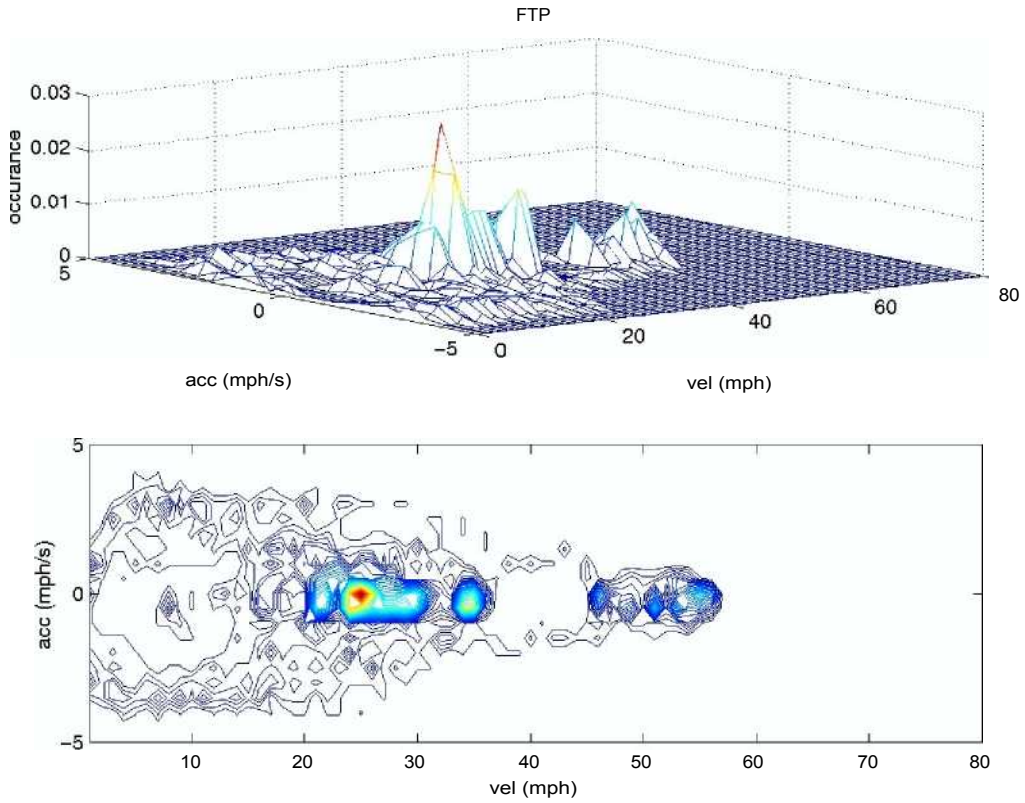


Figure 5.2 - FTP Driving Pattern Used for Vehicle Emissions Analysis

As can be clearly noted, the FTP cycle contains much higher speeds than were measured in Zion National Park and uses a much wider range of accelerations and decelerations than was observed in the Park. The new US06 cycle will exacerbate this difference even further.

The differences in distributions in speeds observed in the Park and between the FTP in the preceding sections were tested for statistical significance using the Kolmogorov-Smirnov two sample test (Siegel, 1956). The test is a non-parametric test for differences in distribution, which is sensitive to all types of differences and does not assume any particular underlying statistical distribution. The distribution of speeds at Zion National Park is significantly different from that of the FTP ($p<0.0001$). These results are summarized in Table 5.5.

Table 5.5 - Summary Statistics and K-S Test Results for Zion Speed Distributions

Speed Interval (mph)	Zion Cumulative (Percent)
0 – 5	34.15
5 - 10	37.89
10 - 15	42.26
15 – 20	58.80
20 – 25	79.88
25 – 30	93.01
30 – 35	97.64
35 – 40	99.14
40 – 45	99.99
45 - 50	100.00
50 - 55	100.00

Comparison of Emission Calculations

The CMEM model is specifically designed to analyze emissions from a specified sequence of speed/acceleration events. This allows the comparison of projected emissions associated with the driving patterns measured in Zion National Park with the FTP pattern. The results are shown in Table 5.6. Results were calculated for two types of vehicles. Category 11 vehicles in the CMEM model refer to newer high power to weight gasoline-powered vehicles (e.g. a 1998 Ford Taurus), which is similar to the dominant passenger cars observed in the parks. Category 17 vehicles in the CMEM model refer to newer full sized pickup trucks and SUVs, which are representative of the dominant larger vehicles in the parks. As can be seen in Table 5.6, the relative results between the two categories of vehicles are very similar. However, there is a significant difference between parks.

Table 5.6 - Projected Tailpipe Emissions (grams/mile) for Measured Driving Cycles and Comparisons with the FTP Driving Cycle

Vehicle Emission Category	FTP	Zion	Zion/FTP Ratio
CMEM Cat 11 HC (g/mi)	0.012	0.013	1.083
CMEM Cat 17 HC (g/mi)	0.059	0.047	0.797
CMEM Cat 11 CO (g/mi)	0.37	0.74	2.000
CMEM Cat 17 CO (g/mi)	0.89	1.06	1.191
CMEM Cat 11 NOx (g/mi)	0.14	0.1	0.714
CMEM Cat 17 NOx (g/mi)	0.21	0.14	0.667
CMEM Cat 11 Fuel (g/mi)	137.8	115.4	0.837
CMEM Cat 17 Fuel (g/mi)	176.3	146.1	0.829

As can be seen in Table 5.6, the emissions of HC and CO within Zion National Park are projected to be significantly greater than the FTP urban driving cycle, but NOx emissions are projected to be significantly lower. This analysis illustrates the problem of simply applying the traditional MOBILE and EMFAC models to park situations.

Overall Estimated Vehicle Emissions

Both the fleet distribution and driving patterns can significantly affect vehicular emissions. The US EPA's MOBILE5b model was used to estimate several scenarios; using a base case, using Park derived fleet distribution data, and using Park derived fleet distribution data and Park derived driving pattern data (EPA, 1994). Both a summer time and a wintertime scenario were calculated for both Zion and Arches National Parks.

The input data for the baseline scenario was obtained from Utah's Mountain lands Association of Governments (WFRC, 2000). There are several different I/M programs in place in various nonattainment counties of Utah, and each one is modeled slightly different. Although the Zion and Arches National Parks themselves do not lie within nonattainment counties, most of the vehicles visiting them come from nonattainment counties and are therefore subjected to an I/M program of one form or another. For the purposes of this analysis, the basic Utah I/M program with technician training credits (TTC) and a percentage of oxygenates in gasoline, similar to the programs in Weber and Utah counties, was assumed for this analysis. Appendix C shows the MOBILE and PART5 input files used for each scenario. Since the State Implementation Plan for Utah's air quality focuses on wintertime emissions in broad areas, there was limited data on temperatures specifically in the Parks. Therefore, the average summertime and wintertime weather data was obtained from Utah's Weather Service (Pope, 1996). Both Parks were modeled as high-altitude regions. The national default for all other inputs, such as the fraction of cold start, warm start and running emissions, were used where no other data was available or Utah's modeling was consistent with the national default.

The effect of fleet distribution was first estimated independently from driving behavior. Tables 5.7-5.10 show emissions resulting from the EPA and Utah's default fleet distribution, compared with emissions with the Park-specific vehicle type and model year distribution. Emissions at two speeds are shown to demonstrate this effect is relatively speed independent. The speeds selected here are 20 and 57 mph, these correspond to the speeds used for the Local and Freeway speeds used to estimate Utah's mobile emissions. This analysis was limited to the in-park private vehicle fleet, which excluded propane operated shuttle buses, gasoline and diesel government vehicles, as well as tour buses and off-road equipment. Emissions from these additional vehicles are included in the final emission analysis below.

The difference in the age and vehicle class distribution of the Parks results in lower emissions for all pollutants and vehicle classes at all speeds. VOC and CO emissions range from about 34 to 48 percent lower than the baseline case, and NOx emissions are about 53 percent lower than the baseline (5.11). Particulate matter emissions are not affected by speed or temperature changes. Emissions throughout this section will be compared with a "baseline" estimate, which is designated as the MOBILE derived emission factors without driving or fleet corrections applied.

Table 5.7 - Percent Change in Emissions from Baseline using National Park Fleet Distribution Data

	20 mph		57 mph	
	Summer	Winter	Summer	Winter
VOC	-37%	-45%	-34%	-45%
CO	-39%	-37%	-48%	-46%
NOx	-54%	-53%	-54%	-53%
PM	-22%	-22%	-22%	-22%

The effects of driving patterns on emissions were addressed in two ways. First, the average speed of the Park's consolidated driving trace was modeled in MOBILE5b. This is an oversimplification of the complex effect of acceleration and driving pattern but gives an idea of the potential impact on emissions. Table 5.8 displays the percent change in emissions for the driving pattern observed at the park compared with the FTP driving trace.

Table 5.8 - Comparison of Average Speed to Emissions Using National Park Fleet Distribution and MOBILE emissions model compared with the FTP Cycle

	Zion 16.7 mph	
	Summer	Winter
VOC	14%	10%
CO	9%	9%
NOx	2%	2%
PM	14%	10%

The MOBILE model predicts that VOC and CO emissions will be slightly higher than the default values in Zion. NOx emissions are virtually unaffected.

The impact of the variations in the driving pattern can also be illustrated using the results of the CMEM model. Since the MOBILE model estimates emissions based on the FTP cycle, the ratio of the emissions from the Park-specific driving cycle to the FTP driving cycle estimated in CMEM (shown in Table 5.3) can be applied to the MOBILE calculated emissions at the average speed of the FTP cycle. The driving cycle correction for Category 11 was applied to LDGV, and Category 17 corrections were applied to LDGTs. While the CMEM and MOBILE categories are not an exact match, this is the closest approximation possible. Other MOBILE categories were not corrected for driving pattern data in the table seen below. The emissions are displayed in Table 5.9

Table 5.9 - Effect of Driving cycle as calculated by CMEM on vehicle emissions using the National Park Fleet Distribution compared with the FTP cycle

	Zion 16.7 mph	
	Summer	Winter
VOC	1%	0%
CO	69%	66%
NOx	-25%	-25%
PM	1%	0%

To estimate the on-road emissions within the park, it is necessary to include emissions from government operated vehicles in the park, and other vehicles, and to obtain an estimate of the number of miles traveled by each vehicle within the fleet.

Shuttle Bus Fleet

As noted earlier, Zion National Park has begun a propane powered shuttle bus system that operates both within the town of Springdale and in the park. Within the park, the shuttle buses operate on a route between the Visitors' Center and the Temple of Sinawava that presently includes six intermediate stops along both legs of the round trip. 2000 was the inaugural year for the shuttle bus system with operation beginning on May 23. In future years, the shuttles are planned to operate from the beginning of April to the end of October. Currently 16 shuttle buses equipped with trailers are used to provide 119 round trips each weekday and 123 round trips each Saturday and Sunday. Records maintained by the company operating the shuttle bus system containing the total miles traveled during the summer indicate the shuttle buses traveled 255,780 miles over the summer period (May 23 - October 9), which averages to 1,827 miles per summer day. This initial year of shuttle operation was an abbreviated year. For purposes of emissions estimation and emissions benefits, emissions for a complete operating season (April through October – 214 days) were calculated based on the daily miles traveled during the 140 days of actual operation in 2000.

Emissions from liquefied petroleum gasoline (LPG) buses can vary greatly, dependent upon the technology status of the vehicle and the maintenance condition (CEC, 1997; BABFO, 2000; CEC, 2000). To determine the exact emissions from the park buses, it would be necessary to test the buses, however, this was beyond the scope of the project. Therefore, the certification test values for the same type of LPG engine was obtained from Cummins Engine Company (Appendix C). The vehicle tested was also equipped with a catalyst identical to what is used in Zion National Park. Combining the emissions with the activity data shown above, emissions from the shuttle buses were estimated (Table 5.10).

Table 5.10 - Emissions from Park-operated LPG Shuttle Buses (Summer operation only)

Pollutant	Emissions (Tons/day)
VOC	0.007
CO	0.001
NOx	0.020
PM	0.0001

Independent Tour Buses

Independent Tour Buses, which were not included in the fleet distribution and were not a part of the shuttle bus service, were estimated separately. Emission factors were estimated from MOBILE and the VMT and other factors are documented in Appendix C. The tour buses were assumed to be heavy-duty diesel trucks. The overall emissions for

tour buses are shown in Table 5.11. The VOC emissions documented here include evaporative and tailpipe emissions.

Table 5.11 - Emissions from Tour Buses in Zion National Park (Tons/day)

	Baseline		Zion	
	Summer	Winter	Summer	Winter
VOC	0.0021	0.0007	0.0022	0.0008
CO	0.0079	0.0028	0.0087	0.0030
NOx	0.0048	0.0017	0.0039	0.0014
PM	0.0003	0.0001	0.0003	0.0001

Government Vehicle Fleet

Based on information contained in the response to the recent NPS Air Quality/Emissions Survey, Zion National Park is equipped with 85 gasoline light duty vehicles and 5 diesel vehicles. The gasoline vehicles were assumed to be 50% light duty vehicles and 50% light duty trucks, and the diesel vehicles were assumed to be 50% light and 50% medium duty trucks. Emission factors were estimated in MOBILE. Daily VMT estimates were estimated based off of fuel use estimates from the Park service and fuel economy estimates from the EMFAC model (Table 5.12). The VOC emissions documented here include evaporative and tailpipe emissions.

Table 5.12 - Emissions from On-Road Government Vehicles in Zion National Park, Tons/day

	Summer		Winter	
	Baseline	Zion	Baseline	Zion
VOC	0.0127	0.0098	0.0046	0.0035
CO	0.0708	0.0514	0.0400	0.0305
NOx	0.0069	0.0049	0.0057	0.0042
PM	0.0003	0.0003	0.0001	0.0001

Private Vehicle Fleet

The private vehicles entering Zion Park are calculated to travel a total of 28,000 miles per day during the summer and over 19,000 miles per day during the winter. The park specific vehicle class and age distributions were used in conjunction with MOBILE to calculate emission factor specific for Zion, whereas the Baseline estimate uses EPA and SIP standard fleet distribution data. The activity data from the parks combined with the emission factors gives an estimate of the average daily on-road emissions (Table 5.13). The VOC emissions documented here include evaporative and tailpipe emissions.

Table 5.13 - Emissions from Privately Owned Vehicles in Zion National Park, Tons/day

	Summer		Winter	
	Baseline	Zion	Baseline	Zion
VOC	0.140	0.101	0.049	0.030
CO	0.783	0.522	0.486	0.333
NOx	0.067	0.031	0.052	0.025
PM	0.001	0.0008	0.001	0.0005

Total Inventory of Vehicle Emissions

The sum of the privately owned vehicles, government vehicles, and alternative fueled vehicles and tour buses make up the overall on-road inventory in each park (Table 5.14-5.15). The tables display a range of inventory options. The baseline scenario uses national fleet distributions. The Park scenarios use Park-specific fleet distributions and an average speed correction factor calculated by the driving data collected at each Park.

Table 5.14 - Daily On-Road Emissions for Zion National Park (tons/day)

	Summer		Winter	
Pollutant	Baseline	Zion	Baseline	Zion
VOC	0.161	0.120	0.054	0.034
CO	0.863	0.582	0.529	0.367
NOx	0.098	0.060	0.060	0.031
PM	0.001	0.001	0.001	0.001

Off-Road Mobile Emissions

Park personnel provided estimated hours of operation for off-road equipment. It was assumed that, on average, fuel consumption by this equipment is 1 gallon per hour. Based on this assumption, total fuel consumption was estimated and used in conjunction with AP-42 off-road emission factors to approximate emissions from off-road equipment. The calculated emissions were apportioned equally throughout the year (Table 5.16-5.17).

Table 5.15: Summary of Emissions from On-Road Mobile Sources

Item		Season	Visitor Miles per Month	Tour Bus Miles per Month	Government Miles per Month	Shuttle Miles per Month	Total Miles
On-Road Mobile		Summer	839,968	11,321	86,125	54,810	992,224
		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Visitor Vehicles		46.3	46.3	6,036.9	1,851.8	31,295.6	0.0
Tour Buses		16.2	16.2	134.8	232.4	521.6	0.0
Government Vehicles		15.8	15.8	586.7	296.2	3,083.5	0.0
Shuttle Buses		6.8	6.8	415.7	1,190.2	36.3	0.0
		TSP	PM10	VOC	NOX	CO	SOx
Totals	**Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		85.1	**85.1**	**7,174.1**	**3,570.6**	**34,937.1**	**0.0**

Item		Season	Visitor Miles per Month	Tour Bus Miles per Monts	Government Miles per Month	Shuttle Miles per Month	Total Miles
On-Road Mobile		Winter	586,355	3,956	56,361	0	646,672
		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Visitor Vehicles		32.3	32.3	1,771.0	1,499.5	20,036.7	0.0
Tour Buses		5.7	5.7	47.1	81.2	182.3	0.0
Government Vehicles		6.7	6.7	211.2	248.5	1,832.8	0.0
Shuttle Buses		0.0	0.0	0.0	0.0	0.0	0.0
		TSP	PM10	VOC	NOX	CO	SOx
Totals	**Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		44.7	**44.7**	**2,029.3**	**1,829.2**	**22,051.8**	**0.0**

		On-Road					
		TSP	PM10	VOC	NOX	CO	SOx
Season:	**Summer**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		85.1	**85.1**	**7,174.1**	**3,570.6**	**34,937.1**	**0.0**
		TSP	PM10	VOC	NOX	CO	SOx
Season:	**Winter**	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)	(lbs/month)
		44.7	**44.7**	**2,029.3**	**1,829.2**	**22,051.8**	**0.0**

Table 5.16: Emissions from Off-Road Mobile Sources

Item	Season	Number of Chainsaws	Average Use (hours/month)	Number of Weed Wackers	Average Use (hours/month)	Number of Lawnmowers	Average Use (hours/month)	Number of Power Wheelbarrows	Average Use (hours/month)	Number of Compressors	Average Use (hours/month)
Small Off-Road Equipment	Summer	10	8.3	6	2.5	1	6.7	1	2.5	1	

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Chainsaws	0.4	0.4	16.9	0.1	49.8	0.0
Weed Wackers	0.1	0.1	5.1	0.0	*15.0*	*0.0*
Lawnmower	*0.0*	*0.0*	1.5	0.2	*30.9*	*0.0*
Powered Wheelbarrow	*0.0*	*0.0*	0.6	0.1	11.5	0.0
Compressor	*0.0*	*0.0*	*0.0*	*0.0*	0.0	0.0
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.6	**0.6**	**24.0**	**0.3**	**107.1**	**0.0**

Item	Season	Number of Chainsaws	Average Use (hours/month)	Number of Weed Wack.	Average Use (hours/month)	Number of Lawnmowers	Average Use (hours/month)	Number of Pw. Wheelbarrows	Average Use (hours/month)	Number of Compressors	Average Use (hours/month)
Small Off-Road Equipment	Winter	10	8.3	6	2.5	1	6.7	1	2.5	1	

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Chainsaws	0.4	0.4	16.9	0.1	49.8	0.0
Weed Wackers	0.1	0.1	5.1	0.0	*15.0*	*0.0*
Lawnmower	*0.0*	*0.0*	1.5	0.2	*30.9*	*0.0*
Powered Wheelbarrow	*0.0*	*0.0*	0.6	0.1	11.5	0.0
Compressor	*0.0*	*0.0*	*0.0*	*0.0*	0.0	0.0
Totals Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.6	**0.6**	**24.0**	**0.3**	**107.1**	**0.0**

Item	Season	Number of Snowmobiles	Average Use (hours/month)	Number of All Terrain	Average Use (hours/month)	Number of John Deer	Average Use (hours/month)	Number of Front Loader	Average Use (hours/month)
Large Off-Road Equipment	Summer	2	2.5	2	16.7	1		1	

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Snowmobiles	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	0.0
All Terrain Vehicle	*0.0*	*0.0*	*0.2*	*0.0*	*0.4*	0.0
John Deer Tractor	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0
Front Loader	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0
Totals Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.2**	**0.0**	**0.5**	**0.0**

Item	Season	Number of Snowmobiles	Average Use (hours/month)	Number of All Terrain	Average Use (hours/month)	Number of John Deer	Average Use (hours/month)	Number of Front Loader	Average Use (hours/month)
Large Off-Road Equipment	Winter	2	2.5	2	16.7	1		1	

	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Snowmobiles	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	0.0
All Terrain Vehicle	0.0	0.0	0.2	0.0	0.4	0.0
John Deer Tractor	0.0	0.0	0.0	0.0	0.0	0.0
Front Loader	0.0	0.0	0.0	0.0	0.0	0.0
Totals Season	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
	0.0	**0.0**	**0.2**	**0.0**	**0.5**	**0.0**

Off-Road

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Season:	Summer	**0.6**	**0.6**	**24.2**	**0.3**	**107.6**	**0.0**
Season:	**Winter**	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		0.6	**0.6**	**24.2**	**0.3**	**107.6**	**0.0**

Table 5.17: Evaporation from Off-Road Devices

Off-Road Device	Number of Units	Hours per Month of Use	VOC Factor	VOC (lbs/month)
	Summer			
Chainsaws	10	8.3		0.0
Snowmobiles	2	2.5	18	2.4
Weed Wackers	6	2.5	0.54	0.2
All Terrain Vehicles (6 wheel polaris)	2	16.7	18	2.4
Lawnmower	1	6.7	1.16	0.1
Powered Wheelbarrow	1	2.5	1.16	0.1
John Deer Tractor with Shovel	1		94.5	6.2
Compressor	1		3.38	0.2
Front Loader	1		94.5	6.2
Sub-Total	**Summer**			**17.8**

Off-Road Device	Number of Units	Hours per Month of Use	VOC Factor	VOC (lbs/month)
	Winter			
Chainsaws	10	8.3		0.0
Snowmobiles	2	2.5	18	2.4
Weed Wackers	6	2.5	0.54	0.2
All Terrain Vehicles (6 wheel polaris)	2	16.7	18	2.4
Lawnmower	1	6.7	1.16	0.1
Powered Wheelbarrow	1	2.5	1.16	0.1
John Deer Tractor with Shovel	1		94.5	6.2
Compressor	1		3.38	0.2
Front Loader	1		94.5	6.2
Zeptox				
Sub-Total	**Winter**			**17.8**

Total Miscellaneous Off-Road Evaporative Emissions	
	VOC
Summer	(lbs/month)
	17.8
	VOC
Winter	(lbs/month)
	17.8

Chapter Six – Environmental Benefit of Shuttle Bus System

Currently there are 16 shuttle buses with trailers that provide 119 round trips each weekday and 123 round trips each Saturday and Sunday in Zion National Park. Records maintained by the company operating the shuttle bus system contain the total miles traveled and the total number of passengers transported by the shuttle buses between May 23 and October 9, 2000. Because of the data that is recorded, there is no precise method available to calculate the actual number of individuals transported since a single person could be counted multiple times. Based upon the advice of Mr. Kirk Scott, the manager of the shuttle bus service, it is felt that dividing the total number of passengers recorded by three can approximate a reasonable estimate of individual ridership. Monthly vehicle occupancy factors developed by the National Park Service, specific to Zion National Park, indicate the average ridership during the April through October time period is 2.5. Responses to a recent National Park Service Air Quality/Emissions Survey provide an estimate of the average number of miles each non-shuttle vehicle travels within Zion National Park during both the operating season and non-operating season for the shuttle bus system (Table .6.1). Vehicle counts taken at the South and East entrances provide the number of actual vehicles. With this information, it is possible, as shown in Table .6.2 to estimate the total number of non-shuttle vehicles and resultant vehicle miles traveled that is avoided by operation of the shuttle bus system.

Table 6.1 - Average VMT/Visit (non-shuttle vehicles

Visitor Entering	Average Distance Traveled (miles)/Visit		
	Shuttle Operating (April-Oct.)	Shuttle not Operating (Nov.-March)	Year Round
South Entrance	4.2	16	
East Entrance	14.3	19.7	
Kolob Canyons			9.5
Kolob Terrace			13

Table 6.2 - Passenger Information on Zion National Park Shuttle Bus Service

Total Passengers	Total Individuals/Day	Total Vehicles Avoided/Day	Total Miles Avoided/Day
1,256,249	2,994	1183	10,877

Use of the emissions calculated for the National Park vehicle fleet allows an estimation of the total benefit to the environment due to pollutant emissions avoided by operation of the shuttle bus system (see Table 6.3). The table shows that on-road vehicle VOC, CO, and PM emissions are reduced as a result of the shuttle bus system. However, NOx emissions increase from shuttle operation because of the relatively high emissions (almost 10x) compared with passenger vehicles. The air quality benefits of the shuttle bus system are quite likely to be understated since the effects of traffic congestion on the Zion Canyon Scenic Drive that would exist in the absence of the shuttle system have not been quantified.

Table 6.3 - Emissions Change from Shuttle Bus Implementation (Tons/Summer day)

Pollutant	Tons/day	Percent of Total On-Road Emissions
VOC	-0.032	-27%
CO	-0.202	-35%
NOx	0.008	13%
PM	0.000	-13%

Chapter Seven – Utah Air Quality Rules Review

The Utah Department of Environmental Quality has full delegation of EPA's air programs **(PSD, NSR,** Title V, NESHAPS, NSPS, etc). As a result, compliance with UDEQ's air quality requirements represents compliance with federal requirements as well. Zion National Park is not located within non-attainment areas for any of the criteria pollutants. Therefore, the lower applicability levels and special requirements placed on sources within non-attainment areas are not an issue of concern for this review. Since Zion National Park is classified as a Class-I Area, sources and activities within the Park have the potential to impact a Class-I area. Thus, the applicability of PSD requirements for Class-I areas is worthy of review. UDEQ's Division of Air Quality has adopted a permit program that has statewide applicability. For this reason, a review of the point sources operating within the Park is also in order. Lastly, individual rules may have emission or operating requirements and deserve review in regard to sources and activities known to exist within the Park.

R307-405, Permits: Prevention of Significant Deterioration of Air Qualty (PSD), section 6 "PSD Areas – New Sources and Modifications" provides a list of the requirements for major sources. No sources within the Park meet the rule's definition of major. The rule indicates that, "a proposed source or modification which is not a major source or major modification may be approved without meeting the requirements [of this rule] provided such source meets all other applicable requirements of these regulations. In effect, PSD requirements have no meaningful applicability to the non-major sources operating within the Park since they are already governed by the other regulations.

R307-401, Permit: Notice of Intent and Approval Order would, on its face, appear to be applicable to sources within the Park. However, R307-413, Exemptions and Special Provisions, provides an exemption for sources who actual emissions of SO2, NO2, PM, CO, or VOC are less than 5 tons per year and whose potential to emit does not make it a major source. Sources of toxic emissions would only be exempt from R307-401 if their annual emissions are less than 500 lbs per individual hazardous pollutant or 2000 lbs for any combination of hazardous pollutants. The only point source considered to warrant a comparison to these requirements is the distillate oil-fired boiler at Zion Lodge. The boiler has a rated heat input capacity of 1.9 MM Btu/hour. Distillate fuel oil has a heating value of 130,000 Btu/gallon. Thus, the maximum operating rate for the boiler would consume 14.6 gallons of distillate fuel oil. If one assumed the maximum fuel consumption all of the 8760 hours in a year, the calculated emissions would appear as follows:

Table 7.1: Zion Lodge Boiler Potential Emissions[1]

Annual Throughput (gallons)	Pollutant	Factor	Lbs/year	Tons/year
128,031	PM10	2	256	0.13
	TSP	2	256	0.13
	VOC	0.34	44	0.02
	NOx	24	3073	1.54
	CO	5	640	0.32
	SO2	157S	603	0.30
		Totals	4872	2.44

As can be seen from the above, NOx represents the pollutant with the greatest emission potential and it is less than half of the applicability threshold. Thus, rule 401 would not appear to be applicable to current sources within the Park.

Rule 201 establishes 20% opacity requirements that would be applicable to the distillate oil-fired boiler at Zion Lodge and the waste oil burner within the maintenance yard.

Rule 202 would govern the open pile burning that is carried out by Park personnel on a semi-annual basis within the Watchman Bone Yard. This rule would require that a permit be obtained prior to burning. Park personnel, at the time of the onsite visit, indicated they obtain the necessary permits prior to each burn. While not specifically listed, prescribed burning would appear to be governed under the section of the rule that allows a burn permit to be granted for a written application in the event the burning is not inconsistent with the State Implementation Plan (SIP). A discussion with a staff member of the Utah air quality division indicated Zion National Park personnel are very conscientious in obtaining the necessary burn permits prior to burning.

Rule 203 requires that the Park maintain a record of their fuel oil purchases that includes the weight percent sulfur, gross heating value, and density.

Rule 205 places requirements for dust suppression for material storage, handling, or hauling operations and land clearing of an area greater than one-quarter of an acre. This could have impact on activities within the Park such as the cinder storage piles between the visitor center parking lot and the Watchman residential area.

[1] Based on emission factors taken from Tables 1.3-1, 1.3-3, and 1.3-7 in 1.3 "Fuel Oil Combustion" of EPA Doc. AP-42

Chapter 8 - Mitigation of Park Emissions

While emissions from National Parks are relatively low, there are a number of options to even further lower emissions and teach the public by example and experience about good environmental stewardship. Table 8.1 below provides information on a number of mitigation options that should be considered along with contact information in most cases. A specific discussion of Zion mitigation activities and future opportunities can be found following Table 8.1.

Table 8.1: Mitigation Strategies for Electricity, Cooking and Heating, and Solvent Use Activities

Mitigation Strategies	Comment	Potential Source of Information
Solar Voltaic Panels	Reduce electricity use. Since most electricity is imported, this will not reduce in-park emissions.	www.nrel.gov/ncpv/, www.fsec.ucf.edu/, www.shell.com/home/Framework?siteId =shellsolar
Wind Generation	Reduce electricity use. Since most electricity is imported, this will not reduce in-park emissions. Limited to areas with higher wind potential. Some visual imparement.	http://rredc.nrel.gov/, www.awea.org/
Solar Thermal Panels	Reduce fuel use in the park. Can displace wood, propane, natural gas, and fuel oil use.	http://rredc.nrel.gov/www.meca.org, www.fsec.ucf.edu/
Low NOx Water Heaters	Reduce NOx emissions within the park where propane and other fossil fuels are used to provide hot water.	www.aqmd.gov/tao/R1146Table.htm, www.environmentalchoice.com/, www.combustion-net.com/
Low NOx Boilers	Reduce NOx emissions within the park where propane and other fossil fuels are used for space heating.	www.aqmd.gov/tao/R1146Table.htm, www.environmentalchoice.com/, www.combustion-net.com/
Low NOx Retrofit for Boilers	In some cases, existing boilers can be retrofit with new burners to reduce NOx emissions.	www.alzeta.com/index.html, www.aqmd.gov/tao/R1146Table.htm
Low NOx Retrofit for Water Heaters	Retrofits are not normally available or practical for smaller water heaters, but in the case of larger units, it is possible to retrofit units to reduce emissions.	www.alzeta . ml, www.aqmd.gov/tao/RI R1 1 46Table.htm
Waterbase Coatings and Caulks.	A variety of low VOC coatings and caulks are now becoming available. Some of these coatings have zero emissions. Care should be taken in selecting coatings because the outside performance of some of the coatings are poor.	www.aqmd.gov/tao/cas/prolist.html, www.aq /business/water.html, www. anairco www.environ entalchoictalchoice.com/
Waterbase Solvent Cleaning Units	Very affordable waterbase parts cleaning is now available for vehicle and other similar maintenance operations.	www.aqmd.gov/tao/cas/prolist.html, www.aqmd.gov/business/water.html
Low VOC Consumer Products	There are some lower emitting VOC products now coming onto the market. These vary from low voc fire starting products to residential cleaning solvents and pesticides. Use of and marketing of these products in parks can reduce emissions.	www.aqmd.gov/tao/cas/prolist.html, www.aqmd.gov/business/water.html, www.arb.ca.gov/consprod/regs/regs.htm
Fluoresent Lights and Energy Efficiency	Fluoresent lights are now available in a range of sizes and shapes and reduce electricity consumption by 80% for equivalent lighting. There are a number of other business, commercial, and residential products that will save energy and reduce fuel and elec	www.eren.doe.gov/, www.simkar.com/, www.lamarlighting.com/, www.energystar.gov/products/
Cooking Controls	Commercial cooking has been found to be the source of significant emissions. New types of cooking hoods with catalytic controls are now available to reduce cooking emissions that have proved to be very effective. Two companies who have approved technologies are Engelhard and Ayrking/Prototech.	email rpatel@aqmd.gov

Table 8.1 cont: Mitigation Strategies for Fuel Use and Vehicles

Mitigation Strategies	Comment	Potential Source of Information
Low Sulfur Fuel	While propane and natural gas are already low sulfur, fuel oils and diesel fuels can have high sulfur content. Specification of low sulfur fuels for vehicles and heating applications can significantly reduce sulfur emissions.	http://ecdiesel.com/decade.html
Clean Fuel	There are a number of California approved conversion kits to convert gasoline vehicles to propane and natural gas. These conversions can provide lower emissions. Caution should be applied in this area. Some of the conversions of vehicles have proved not t	www.afdc.doe.gov/
Clean Gasoline	California has set strict requirements for gasoline which lowers evaporative and running emissions from vehicles. These fuels cost a few cents more a gallon. Transportation cost may not be a problem for parks in Arizona and Utah. New ethanol based oxygena	www.afdc.doe.gov/
Clean Diesel	Arco has announced the development of a cleaner burning diesel fuel that significantly reduces emissions. In addition, Lubrizol has produced a water emulsified fuel for diesel vehicles that reduces	www.afdc.doe.gov/, www.lubrizol.com/PuriNOx/default.htm, www.afdc.doe.gov/altfuel/biodiesel.html
Clean Vehicles	New ULEV and SULEV vehicles burn gasoline but produce 0.01% of the emissions of past vehicles. They are even 10 times cleaner than typical 2002 national vehicles. The use of these vehicles by the park service would be even cleaner than propane and natural	www.arb.ca.gov/msprog/ccbg/ccbg.htm, www.zevinfo.com/, http://www.epa.gov/autoemissions/, www.calstart.org/calindex3.html
Diesel Vehicle Retrofit Controls	Particulate filters are now available to reduce particulate emissions from diesel vehicles by more than 90%. There are several varieties of these filters. There is also retrofit NOx controls but they require fuel sulfur below 50ppm and are much more expen	www.meca.org/jahia/Jahia

Table 8.1: Mitigation Strategies for Road Paving, Wood Burning, and Waste Handling

Mitigation Strategies	Comment	Potential Source of Information
Recycling	In cases where parks must provide for their own waste disposal, recycling is an effective way to reduce this need. Recycling also saves resources and offers a chance for parks to demonstate to the public good environmental practices.	
Open Burning Timing	Burning is an important part of forest management. However, for prescribed fires, there is some choice in the timing of burning. State regulations typically limit prescribed fires to times when air dispersion is good. In addition to following State requir	
Camp Fire Controls	Campfires are important to many park visitors; however, they are already limited in many parks. The types of wood that can be burned in campfires can be defined. The park service could require that only park provided wood be used and then select wood that	
Road Paving and Unpaved Roads	Road paving can produce significant levels of VOC emissions. They can be mitigated by using slower cure asphalt patching compounds. Another strategy is to minimize paving when pratical to late fall, early spring and winter when ozone formation potential i	www.arb.ca.gov/drdb/ed/curhtml/r224.htm, www.aqmd.gov/rules/html/r1186.html, www.epa.gov/ttn/chief/ap42/ch04/final/c4s05.pdf, www.epa.gov/owow/nps/unpavedroads.html
Waste Dump Generated Methane	Electricty is being produced in many locations from methane generated in the decay of waste. New microturbines provide an opportunity even in cases where methane production is limited.	www.microturbine.com/
Lower Emitting Fireplaces and Wood Stoves	Oregon and Colorado have set standards to produce lower emitting wood burning appliances. These units use catalysts and other processes to significantly reduce emissions.	www.eren.doe.gov/consumerinfo/refbriefs/bb5.html, http://muextension.missouri.edu/explore/agguides/agengin/g01733.htm, www.epa.gov/compliance/resources/publications/monitoring/programs/woodstoves/certifiedwood pdf, www.cdphe.state.co.us/ap/woodstoves.asp
Fireplace and Wood Stove Retrofits	Inserts are available that help reduce emissions from fireplaces and wood stoves. Inserts may not be available for all fireplace or stove configurations, but consideration should be given to this option where inserts are available.	www.eren.doe.gov/consumerinfo/refbriefs/bb5.html, http://muextension.missouri.edu/explore/agguides/agengin/g01733.htm, http://www.deq.state.or.us/aq/woodstoves/index.htm, www.cdphe.state.co.us/ap/woodstoves.asp

Zion National Park has undertaken a number of mitigation measures that are worth noting. These include the propane powered shuttle bus system, solar electric power at various locations, the cooling tower system within the new visitors center, woodstove upgrade to new cleaner-burning woodstoves, and the use of low solvent cleaning fluids in some cases. Additional mitigation measures for consideration include replacement of the

distillate fuel oil-fired boiler at the lodge with a lower-emitting propane-fired boiler, elimination of the waste oil burner, complete conversion from incandescent lighting to fluorescent lighting, paving of unpaved road sections, and street sweeping.

Appendix A

Emission Factors for Estimation of Park Emissions

Some of the most critical parameters for estimating emissions from the National Parks are the emission factors for the various processes that take place in the park. The development of emission factors for on-road mobile sources is discussed in detail elsewhere and will not be discussed in this portion of the report. Sources in Zion National Park for which factors must be determined are shown in Table A.1.

Table A.1: Source Types found in Zion National Park

On-Road Mobile Sources		
	Light Duty Passenger Vehicles	Heavy Duty Trucks
	Light Duty Trucks	Diesel Powered Buses
	Medium Duty Trucks	Propane Powered Buses
Off-Road Mobile Sources		
	Lawn Mowers	Snowmobiles and Other All Terrain Vehicles
	Weed Whackers	Tractor and Front Loader
	Chain Saws	Compressor
Propane Burning in Stationary Sources		
	Space Heating	Water Heating
Wood Burning		
	Campfires	Refuse Pile
	Wood Stoves	Prescribed Burn
	Fireplaces	Wildfire
Fuel Handling		
	Propane Tank Filling	Gasoline Vehicle Fueling (On- & Off-Road)
	Gasoline Tank Filling	Diesel Vehicle Fueling (On- & Off-Road)
	Diesel Tank Filling	
Oil Burning		
	Space Heating	Waste Oil Heating
	Water Heating	
Food Preparation		
	Broiling	Grilling
Fugitive Dust		
	Re-entrained Dust from Paved Roads	Re-entrained Dust from Unpaved Roads
	Dust from Cinder Piles for Traction in Snow	
Road Maintenance		
	Surfacing Paved Roads	
Solvent Use		
	Use of paints and other solvents	

Off-Road Mobile

Emission factors for off-road mobile sources are some of the most difficult to determine. Interest in emissions from these sources is relatively recent, and inadequate measurements have been made in many cases to characterize emissions. The emission factors for these emission sources were derived from two U.S. EPA studies conducted in

1991 and 1998. Values used and sources of the factors used for off-road mobile sources are shown in Table A.2.

Table A.2: **Emission Factors for Off-Road Mobile Sources**

Lawnmower-4 Cycle Engine (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	1.87	1	1.87	1	1.49	1
	NOx	Reference	CO	Reference	SOx	Reference
	11.9	1	2093	1	2.37	1
Weed Wacker-2 Cycle Engine (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	22.5	1	22.5	1	922	1
	NOx	Reference	CO	Reference	SOx	Reference
	3.59	1	2726	1	1.8	1
Chainsaw-2-Cycle Engine (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	22.5	1	22.5	1	922	1
	NOx	Reference	CO	Reference	SOx	Reference
	3.59	1	2726	1	1.8	1
Snowmobile and Other All Terrain Vehicles (grams emitted per kilowatt hour of energy consumed)	TSP	Reference	PM10	Reference	VOC	Reference
	3.22	2	3.22	2	206	2
	NOx	Reference	CO	Reference	SOx	Reference
	0.63	2	523	2	--	--
Tractor-Gasoline (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	8	1	8	1	1.25	1
	NOx	Reference	CO	Reference	SOx	Reference
	151	1	32600	1	5.31	1
Front Loader-Diesel (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	45.7	1	45.7	1	62.3	1
	NOx	Reference	CO	Reference	SOx	Reference
	439	1	175	1	31.2	1
Compressor (grams emitted per gallon of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	0.16	1	0.16	1	6.2	1
	NOx	Reference	CO	Reference	SOx	Reference
	0.02	1	17	1	--	--

Propane Burning in Stationary Sources

Propane is used at stationary sources primarily for space heating and for water heating. The same factor was used for both cases since it was unclear if the water heating boilers and space heating units were always separate. Further, gas usage factors supplied by the Park were combined and there was no way to determine how much was used for water heating and how much was used for space heating, and how much was used for cooking. Factors used are shown in Table A.3

Table A.3: Emission Factors for Propane Combustion at Stationary Sources

Space, Water Heating, and Cooking (grams emitted per 1000 gallons of fuel used)	TSP	Reference	PM10	Reference	VOC	Reference
	0.4	4	0.4	4	0.3	4
	NOx	Reference	CO	Reference	SOx	Reference
	14	4	1.9	4	10	4

[1] These emission rates were converted to grams emitted per gallon of fuel used using the brake specific fuel consumption of 665 grams per kilowatt-hour provided in the reference. A gasoline density of 6.2 pounds per gallon was used (Ref. 6, page 3-89)

Wood Burning

Wood burning is one of the most difficult to estimate due to the variety of situations in which wood is burned, the individual fire management practices of the user. The type of wood can also have an impact; although, present emission factors ignore this issue. The various emission factors used for this study are shown in Table A.4.

Table A.4: Emission Factors for Wood Burning Activities

Campfires, Fireplaces, and Refuse Piles (pounds of emissions per ton of wood burned)	TSP	Reference	PM10	Reference	VOC	Reference
	34.6	4, Chap 1.9	34.6	4, Chap 1.9	229	4, Chap 1.9
	NOx	Reference	CO	Reference	SOx	Reference
	2.6	4, Chap 1.9	253	4, Chap 1.9	0.4	4, Chap 1.9
Wood Stoves (pounds of emissions per ton of wood burned)	TSP	Reference	PM10	Reference	VOC	Reference
	30.6	4, Chap 1.10	30.6	4, Chap 1.10	53	4, Chap 1.10
	NOx	Reference	CO	Reference	SOx	Reference
	2.8	4, Chap 1.10	231	4, Chap 1.10	0.4	4, Chap 1.10
Prescribed Burn (pounds of emissions per ton of wood burned)	TSP	Reference	PM10	Reference	VOC	Reference
	35.6	4, Chap 13.1	26	4, Chap 13.1	12.1	4, Chap 13.1
	NOx	Reference	CO	Reference	SOx	Reference
	4	4, Chap 13.1	140	4, Chap 13.1	0.1	4, Chap 13.1
Wildfires (pounds of emissions per ton of wood burned)	TSP	Reference	PM10	Reference	VOC	Reference
	17	4, Chap 13.1	11.9	4, Chap 13.1	12.7	4, Chap 13.1
	NOx	Reference	CO	Reference	SOx	Reference
	4	4, Chap 13.1	140	4, Chap 13.1	.1	4, Chap 13.1

Fuel Handling

The fuel-handling category covers the filling of both large and small tanks. It also covers the fueling for vehicles. No vapor recovery is used for any fuel filling in Zion National Park. The emission factors used are shown in Table A.5.

Table A.5: Emission Factors for Fuel Handlin

Propane Tank Filling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	17	5
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Gasoline Tank Filling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	11.5	4, Chap 5.2
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Diesel Tank Filling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	0.03	4, Chap 5.2
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Gasoline Vehicle Fueling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	12.7	4, Chap 5.2
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Propane Vehicle Fueling (pounds emitted per 1000 gallons filled)	TSP	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	3	5
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--

Fuel Oil Burning

Fuel oil burning is conducted in two situations in the Park. The heating system for the Lodge uses distillate fuel oil and the vehicle maintenance center burns its waste oil from vehicles for heat. Distillate fuel oil sulfur content (0.025%) and ash content (0.01%) was obtained through the Park's concessionaire office. The emission factors used to represent these processes are shown in Table A.6.

Table A.6: Emission Factors for Fuel Oil and Waste Oil Burnin

Distillate Fuel Oil Boiler (pounds emitted per 1000 gallons of fuel used. SOx factor must be multiplied by % by weight sulfur in the fuel)	TSP	Reference	PM10	Reference	VOC	Reference
	2	4, Chap. 1.3	2	4, Chap. 1.3	.34	4, Chap. 1.3
	NOx	Reference	CO	Reference	SOx	Reference
	24	4, Chap. 1.3	5	4, Chap. 1.3	157	4, Chap. 1.3
Waste Oil Boiler (pounds emitted per 1000 gallons of fuel used. PM must be multiplied by % by weight ash content of fuel. SOx factor must be multiplied by the % by weight sulfur in fuel.)	TSP	Reference	PM10	Reference	VOC	Reference
	2.8	4, Chap. 1.11	2.8	4, Chap. 1.11	1.0	4, Chap. 1.11
	NOx	Reference	CO	Reference	SOx	Reference
	11.0	4, Chap. 1.11	1.7	4, Chap. 1.11	100	4, Chap. 1.11

Food Preparation

Emission factors for food preparation are in the developmental phase. CE-CERT has done much of the national work to date to quantify emissions associated with broiling and grilling meats. Broiling meat refers to cooking the meat over an open flame where the fat from the meat is allowed to drip into the flame. Grilling meat refers to cooking the meat in a frying pan or on a griddle with no direct contact with the flame. The factors derived for beef broiling were used to represent high fat meat and the factors derived for chicken were used to represent low fat meats. Emission factors used for the study are shown in Table A.7.

Table A.7: **Emission Factors for Food Preparation**

Broiling Meat (beef) (pounds emitted per 1000 pounds of meat cooked)	TSP	Reference	PM10	Reference	VOC	Reference
	32	*7*	*32*	7	3.8	7
	NOx	Reference	CO	Reference	SOx	Reference
Broiling Meat (chicken) (pounds emitted per 1000 pounds of meat cooked)	TSP	Reference	PM10	Reference	VOC	Reference
	2	*7*	*2*	7	0.3	7
	NOx	Reference	CO	Reference	SOx	Reference
Grilling Meat (pounds emitted per 1000 pounds of meat cooked)	*TSP*	Reference	PM10	Reference	VOC	Reference
	5	7	5	7	0.2	7
	NOx	Reference	CO	Reference	SOx	Reference
		7		7		7

Fugitive Dust

The fugitive dust in the Park is associated with re-entrained dust from both paved and unpaved roads. This category of emissions is one of the largest both in the Park and in all urban areas. Because of this, considerable work has been done in an attempt to quantify emissions. Accurate re-entrained emission estimates require explicit knowledge concerning the moisture content of the silt on the road and the average weight of silt on the road surface. The emission factors were developed using the Part5 Model developed by the U.S. EPA (Ref. 8). Since no actual measurements were made in this study, factors used for the state of Utah SIP (Ref 9) of 0.29 grams per square meter were assumed. Rainfall estimates were taken from Utah meteorological data Ref. 10). For the winter 74 days of precipitation were assumed. For the summer 55 days of precipitation were assumed.

For the case of the cinder piles, AP42 provides an emission factor based simply on the size of the pile of cinders.

Emission factors used in this study are shown in Table A.8.

Table A.8: Emission Factors for Re-entrained Dust

Re-entrained Dust from Unpaved Roads (grams emitted per mile driven on the road)	TSP	Reference	PM10	Reference	VOC	Reference
	6.8	4, Chap. 3.2.1	1.4	4, Chap. 3.2.1	n/a	--
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Re-entrained Dust from Paved Roads (grams emitted per mile driven on the road)	TSP	Reference	PM10	Reference	VOC	Reference
	779		280		n/a	--
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--
Dust from Cinder Piles (pounds emitted per acre of exposed pile per day)	TSP	Reference	PM10	Reference	VOC	Reference
	3.5	4, Chap 8.19.1	1.7	4, Chap 8.19.1	n/a	--
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--

Road Maintenance

Road maintenance is a regular part of Park operations. AP42 was used. To make the estimates assumptions had to be made concerning diluent content of the asphalt, which was assumed to be 30%, diluent density, which was assumed to be 0.7 kilograms per liter, an asphalt density of 1.1 kilograms per liter, and the amount of VOC to evaporate of 95%. These values were selected from the mid-range of values in AP42. The resulting emission factors are shown in Table A.9.

Table A.9: Emission Factors for Road Pavin

Road Paving (pounds of emissions per ton of surface material supplied)	*TSP*	Reference	PM10	Reference	VOC	Reference
	n/a	--	n/a	--	0.2	4, Chap. 4.5
	NOx	Reference	CO	Reference	SOx	Reference
	n/a	--	n/a	--	n/a	--

Solvent Use

Solvent use emissions were determined by using actual VOC contents of the paints and solvents used in the Park. The names and manufacturers of the types of materials in use by the Park were collected during Park visits and the manufacturers of those products were contacted and the VOC content information obtained.

References

1. U.S. EPA, Nonroad Engine and Vehicle emission Study-Report, Office of Air and Radiation, November 1991, Report Number EPA-21A-2001
2. U.S. EPA, Exhaust Emission Factors for Nonroad Engine Modeling—Spark Ignition, June 1998, Report Number NR-010A.
3. U.S. EPA, Exhaust Emission Factors for Nonroad Engine Modeling—Compression Ignition, June 1998, Report Number NR-009A.
4. U.S. EPA, Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, October 1996. (www.epa.gov/ttn/chief/ap42/index.html)
5. U.S. EPA, Refueling Emissions for Nonroad Engine Modeling, August 1998, Report Number NR-013.
6. Perry, John H., Chemical Engineers' Handbook, McGraw-Hill, New York, 1963, Library of Congress Number 61-13168.
7. Welsh, B., Development of Emission Test Methods and Emission Factors for Various Commercial Cooking Operations, American Society of Heating, Refrigeration, and Air Conditioning, June 1997.
8. U.S. EPA, Part5 Model Draft User Guide, February 1995 (www.epa.gov/oms/part5.htm).
9. Wasatch Front Regional Council and Mountain Lands Association of Governments, Mobile Source Emissions Inventory Protocol PM10 SIP Development, May 2000.
10. Pope, D., C. Brough (Utah Climate Center), Utah's Weather and Climate, 1996, Publishers Press, 1900 West 2300 Street, Salt Lake City, Utah.

Appendix B

Data Worksheets (Excel)

Table 1.1a: Summary of Summertime Emissions in Zion National Park

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	660.3	660.3	4,359.4	133.4	4,821.1	67.6
	South	498.2	498.2	3,297.6	37.4	3,637.4	5.8
	Lava Point	46.7	46.7	309.2	3.5	341.0	0.5
	Back Country	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	1,205.3	1,205.3	7,966.1	174.4	8,799.6	73.9
Facilities	Zion Lodge	102.4	102.4	12.7	166.3	27.2	85.6
	Old Visitor Center	0.1	0.1	0.1	3.8	0.5	2.7
	Maintenance Yard	0.2	0.2	87.3	5.1	0.7	4.4
	Shuttle Bus Maintenance Yard	0.0	0.0	933.5	0.0	0.0	0.0
	Watchman Bone Yard	346.0	346.0	2,290.0	26.0	2,526.0	4.0
	Grotto House	1.2	1.2	2.1	0.1	9.2	0.0
	Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	Environmental Education Center	0.0	0.0	0.0	0.0	0.0	0.0
	Kolob Canyon Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	East/South/New Walk Entrances	0.0	0.0	0.0	0.0	0.0	0.0
	Rockville Sewage Treatment	0.0	0.0	0.0	0.0	0.0	0.0
	Park Landfill	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	449.9	449.9	3,325.7	201.3	2,563.7	96.6
Residential	Oak Creek	18.4	18.4	31.8	3.5	138.9	1.6
	Watchman	15.4	15.4	26.5	3.7	115.8	1.9
	Kolob Canyon	1.2	1.2	2.1	0.4	9.3	0.2
	Pine Creek	6.1	6.1	10.6	0.6	46.2	0.1
	East Entrance	6.1	6.1	10.6	0.8	46.2	0.3
	Lava Point	0.0	0.0	0.0	0.0	0.0	0.0
	Firepit	0.0	0.0	0.0	0.3	0.0	0.2
	Sub-Total	47.3	47.3	81.7	9.3	356.4	4.2
Evaporative	Solvent Use			29.0			
	Sub-Total	0.0	0.0	29.0	0.0	0.0	0.0
Road Maintenance	Paving			33,320.0			
	Sub-Total	0.0	0.0	33,320.0	0.0	0.0	0.0
Other Area	Cinder Piles	0.7	0.4	0.0	0.0	0.0	0.0
	Prescribed Burning	10,840.2	7,917.0	3,684.5	1,218.0	42,630.0	30.5
	Wildfires	34,884.0	24,418.8	26,060.4	8,208.0	287,280.0	205.2
	Re-entrained Dust, Tire, & Brake Wear	15,040.0	3,080.2	0.0	0.0	0.0	0.0
	Sub-Total	60,764.9	35,416.3	29,744.9	9,426.0	329,910.0	235.7
On-Road	Visitor Passenger Vehicles	46.3	46.3	6036.9	1851.8	31295.6	0.0
	Tour Buses	16.2	16.2	134.8	232.4	521.6	0.0
	Government Vehicles	15.8	15.8	586.7	296.2	3083.5	0.0
	Shuttle Buses	6.8	6.8	415.7	1190.2	36.3	0.0
	Sub-Total	85.0	85.0	7174.1	3570.6	34937.1	0.0
Off-Road	Misc. Equipment	0.6	0.6	42.0	0.3	107.8	0.1
	Sub-Total	0.6	0.6	42.0	0.3	107.8	0.1
	Total Emissions from Park (lbs/month)	62,552.9	37,204.4	81,683.4	13,381.9	376,674.5	410.4
	Total Emissions from Park (tons/day)	1.04	0.62	1.36	0.22	6.28	0.01
	Total Annual Tons of Emissions (Winter plus Summer)	341	207	428	63	1,770	2

Table 1.1b: Summary of Summertime Emissions in Zion National Park (less wildfires)

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	660.3	660.3	4,359.4	133.4	4,821.1	67.6
	South	498.2	498.2	3,297.6	37.4	3,637.4	5.8
	Lava Point	46.7	46.7	309.2	3.5	341.0	0.5
	Back Country	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	1,205.3	1,205.3	7,966.1	174.4	**8,799.6**	73.9
Facilities	Zion Lodge	102.4	102.4	12.7	166.3	27.2	85.6
	Old Visitor Center	0.1	0.1	0.1	3.8	0.5	2.7
	Maintenance Yard	0.2	0.2	87.3	5.1	0.7	4.4
	Shuttle Bus Maintenance Yard	0.0	0.0	933.5	0.0	0.0	0.0
	Watchman Bone Yard	346.0	346.0	2,290.0	26.0	2,526.0	4.0
	Grotto House	1.2	1.2	2.1	0.1	9.2	0.0
	Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	Environmental Education Center	0.0	0.0	0.0	0.0	0.0	0.0
	Kolob Canyon Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	East/South/New Walk Entrances	0.0	0.0	0.0	0.0	0.0	0.0
	Rockville Sewage Treatment	0.0	0.0	0.0	0.0	0.0	0.0
	Park Landfill	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	449.9	449.9	3,325.7	201.3	2,563.7	96.6
Residential	Oak Creek	18.4	18.4	31.8	3.5	138.9	1.6
	Watchman	15.4	15.4	26.5	3.7	115.8	1.9
	Kolob Canyon	1.2	1.2	2.1	0.4	9.3	0.2
	Pine Creek	6.1	6.1	10.6	0.6	46.2	0.1
	East Entrance	6.1	6.1	10.6	0.8	46.2	0.3
	Lava Point	0.0	0.0	0.0	0.0	0.0	0.0
	Firepit	0.0	0.0	0.0	0.3	0.0	0.2
	Sub-Total	47.3	47.3	81.7	9.3	356.4	4.2
Evaporative	Solvent Use			29.0			
	Sub-Total	0.0	0.0	29.0	0.0	0.0	0.0
Road Maintenance	Paving			33,320.0			
	Sub-Total	0.0	0.0	33,320.0	0.0	0.0	0.0
Other Area	Cinder Piles	0.7	0.4	0.0	0.0	0.0	0.0
	Prescribed Burning	10,840.2	7,917.0	3,684.5	1,218.0	42,630.0	30.5
	Wildfires						
	Re-entrained Dust, Tire, & Brake Wear	15,040.0	3,080.2	0.0	0.0	0.0	0.0
	Sub-Total	25,880.9	10,997.5	3,684.5	1,218.0	42,630.0	30.5
On-Road	Visitor Passenger Vehicles	46.3	46.3	6036.9	1851.8	31295.6	0.0
	Tour Buses	16.2	16.2	134.8	232.4	521.6	0.0
	Government Vehicles	15.8	15.8	586.7	296.2	3083.5	0.0
	Shuttle Buses	6.8	6.8	415.7	1190.2	36.3	0.0
	Sub-Total	85.0	85.0	7174.1	3570.6	34937.1	0.0
Off-Road	Misc. Equipment	0.6	0.6	42.0	0.3	107.8	0.1
	Sub-Total	0.6	0.6	42.0	0.3	107.8	0.1
	Total Emissions from Park (lbs/month)	27,668.9	12,785.6	55,623.0	5,173.9	89,394.5	205.2
	Total Emissions from Park (tons/day)	0.46	0.21	0.93	0.09	1.49	0.00
	Total Annual Tons of Emissions (Winter plus Summer)	219	122	336	34	764	1

Table 1.2a: Summary of Summertime Percentages

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	1.06%	1.77%	5.34%	1.00%	1.28%	16.47%
	South	0.80%	1.34%	4.04%	0.28%	0.97%	1.40%
	Lava Point	0.07%	0.13%	0.38%	0.03%	0.09%	0.13%
	Back Country	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	1.93%	3.24%	9.75%	1.30%	2.34%	18.01%
Facilities	Zion Lodge	0.16%	0.28%	0.02%	1.24%	0.01%	20.85%
	Old Visitor Center	0.00%	0.00%	0.00%	0.03%	0.00%	0.65%
	Maintenance Yard	0.00%	0.00%	0.11%	0.04%	0.00%	1.07%
	Shuttle Bus Maintenance Yard	0.00%	0.00%	1.14%	0.00%	0.00%	0.00%
	Watchman Bone Yard	0.55%	0.93%	2.80%	0.19%	0.67%	0.97%
	Grotto House	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Environmental Education Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Kolob Canyon Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	East/South/New Walk Entrances	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Rockville Sewage Treatment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Park Landfill	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	0.72%	1.21%	4.07%	1.50%	0.68%	23.54%
Residential	Oak Creek	0.03%	0.05%	0.04%	0.03%	0.04%	0.38%
	Watchman	0.02%	0.04%	0.03%	0.03%	0.03%	0.45%
	Kolob Canyon	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%
	Pine Creek	0.01%	0.02%	0.01%	0.00%	0.01%	0.02%
	East Entrance	0.01%	0.02%	0.01%	0.01%	0.01%	0.06%
	Lava Point	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Firepit	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%
	Sub-Total	0.08%	0.13%	0.10%	0.07%	0.09%	1.02%
Evaporative	Solvent Use	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%
Road Maintenance	Paving	0.00%	0.00%	40.79%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	40.79%	0.00%	0.00%	0.00%
Other Area	Cinder Piles	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Prescribed Burning	17.33%	21.28%	4.51%	9.10%	11.32%	7.42%
	Wildfires	55.77%	65.63%	31.90%	61.34%	76.27%	**49.99%**
	Re-entrained Dust, Tire, & Brake Wear	24.04%	**8.28%**	0.00%	0.00%	0.00%	0.00%
	Sub-Total	97.14%	95.19%	36.41%	70.44%	87.58%	57.41%
On-Road	Visitor Passenger Vehicles	0.07%	0.12%	7.39%	13.84%	8.31%	0.00%
	Tour Buses	0.03%	0.04%	0.16%	1.74%	0.14%	0.00%
	Government Vehicles	0.03%	0.04%	0.72%	2.21%	0.82%	0.00%
	Shuttle Buses	0.01%	0.02%	0.51%	**8.89%**	0.01%	0.00%
	Sub-Total	0.14%	0.23%	**8.78%**	26.68%	**9.28%**	0.00%
Off-Road	Misc. Equipment	0.00%	0.00%	0.05%	0.00%	0.03%	0.02%
	Sub-Total	0.00%	0.00%	0.05%	0.00%	0.03%	0.02%
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total Emissions from Park	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 1.2b: Summary of Summertime Percentages (less wildfires)

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	2.39%	5.16%	7.84%	**2.58%**	5.39%	32.94%
	South	1.80%	3.90%	5.93%	0.72%	4.07%	2.81%
	Lava Point	0.17%	0.37%	0.56%	0.07%	0.38%	0.26%
	Back Country	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	4.36%	9.43%	14.32%	3.37%	9.84%	36.01%
Facilities	Zion Lodge	0.37%	0.80%	0.02%	3.21%	0.03%	41.69%
	Old Visitor Center	0.00%	0.00%	0.00%	0.07%	0.00%	1.30%
	Maintenance Yard	0.00%	0.00%	0.16%	0.10%	0.00%	2.13%
	Shuttle Bus Maintenance Yard	0.00%	0.00%	1.68%	0.00%	0.00%	0.00%
	Watchman Bone Yard	1.25%	2.71%	4.12%	0.50%	2.83%	1.95%
	Grotto House	0.00%	0.01%	0.00%	0.00%	0.01%	0.01%
	Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Environmental Education Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Kolob Canyon Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	East/South/New Walk Entrances	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Rockville Sewage Treatment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Park Landfill	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	1.63%	3.52%	**5.98%**	3.89%	2.87%	47.08%
Residential	Oak Creek	0.07%	0.14%	0.06%	0.07%	0.16%	0.76%
	Watchman	0.06%	0.12%	0.05%	0.07%	0.13%	0.90%
	Kolob Canyon	0.00%	0.01%	0.00%	0.01%	0.01%	0.11%
	Pine Creek	0.02%	0.05%	0.02%	0.01%	0.05%	0.04%
	East Entrance	0.02%	0.05%	0.02%	0.02%	0.05%	0.12%
	Lava Point	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
	Firepit	0.00%	0.00%	0.00%	0.01%	0.00%	0.10%
	Sub-Total	0.17%	0.37%	0.15%	0.18%	0.40%	2.03%
Evaporative	Solvent Use	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
Road Maintenance	Paving	0.00%	0.00%	59.90%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	59.90%	0.00%	0.00%	0.00%
Other Area	Cinder Piles	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Prescribed Burning	39.18%	61.92%	6.62%	23.54%	47.69%	14.84%
	Wildfires	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Re-entrained Dust, Tire, & Brake Wear	54.36%	24.09%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	93.54%	86.02%	6.62%	23.54%	47.69%	14.84%
On-Road	Visitor Passenger Vehicles	0.17%	0.36%	10.85%	35.79%	35.01%	0.00%
	Tour Buses	0.06%	0.13%	0.24%	4.49%	**0.58%**	0.00%
	Government Vehicles	0.06%	0.12%	1.05%	5.72%	3.45%	0.00%
	Shuttle Buses	0.02%	0.05%	0.75%	23.00%	0.04%	0.00%
	Sub-Total	0.31%	0.67%	12.90%	69.01%	39.08%	0.00%
Off-Road	Misc. Equipment	0.00%	0.00%	0.08%	0.01%	0.12%	0.04%
	Sub-Total	0.00%	0.00%	0.08%	0.01%	0.12%	0.04%
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total Emissions from Park	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 1.3: Summary of Wintertime Emissions in Zion National Park

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	421.7	421.7	2,786.99	**55.6**	3,076.0	22.0
	South	318.9	318.9	2,110.46	24.0	2,328.0	3.7
	Lava Point	18.7	18.7	123.66	1.4	136.4	0.2
	Back Country	0.0	0.0	0.00	0.0	0.0	0.0
	Sub-Total	759.3	759.3	5,021.1	80.9	5,540.4	25.9
Facilities	Zion Lodge	29.3	29.3	3.6	47.5	7.8	24.4
	Old Visitor Center	0.3	0.3	0.2	11.6	1.6	8.3
	Maintenance Yard	0.2	0.2	52.3	1.8	0.2	4.0
	Shuttle Bus Maintenance Yard	0.0	0.0	0.0	0.0	0.0	0.0
	Watchman Bone Yard	484.4	484.4	3,206.0	36.4	3,536.4	5.6
	Grotto House	0.0	0.0	0.0	0.0	0.0	0.0
	Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	Environmental Education Center	0.0	0.0	0.0	0.0	0.0	0.0
	Kolob Canyon Visitor Center	0.0	0.0	0.0	0.0	0.0	0.0
	East/South/New Walk Entrances	0.0	0.0	0.0	0.0	0.0	0.0
	Rockville Sewage Treatment	0.0	0.0	0.0	0.0	0.0	0.0
	Park Landfill	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	514.2	514.2	3,262.2	97.3	3,546.0	42.3
Residential	Oak Creek	**58.3**	**58.3**	100.8	11.1	439.7	4.9
	Watchman	49.2	49.2	**85.0**	11.7	370.6	**5.8**
	Kolob Canyon	0.0	0.0	0.0	0.0	0.0	0.0
	Pine Creek	18.4	18.4	31.8	1.7	138.6	0.2
	East Entrance	24.5	24.5	42.4	2.2	184.8	0.3
	Lava Point	0.0	0.0	0.0	0.0	0.0	0.0
	Firepit	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	150.3	150.3	260.0	26.8	1,133.7	11.3
Evaporative	Solvent Use			29.0			
	Sub-Total	0.0	0.0	29.0	0.0	0.0	0.0
Road Maintenance	Paving			33,320.0			
	Sub-Total	0.0	0.0	33,320.0	0.0	0.0	0.0
Other Area	Cinder Piles	0.7	0.4	0.0	0.0	0.0	0.0
	Prescribed Burning	37,540.0	27,460.0	12,760.2	4,232.0	148,200.0	105.8
	Wildfires	0.0	0.0	0.0	0.0	0.0	0.0
	Re-entrained Dust, Tire, & Brake Wear	9,734.1	1,976.8	0.0	0.0	0.0	0.0
	Sub-Total	47,274.9	29,437.2	12,760.2	4,232.0	148,200.0	105.8
On-Road	Visitor Passenger Vehicles	32.3	32.3	1771.0	1499.5	20036.7	0.0
	Tour Buses	5.7	5.7	47.1	81.2	182.3	0.0
	Government Vehicles	6.7	6.7	211.2	248.5	1832.8	0.0
	Shuttle Buses	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	44.7	44.7	2029.3	1829.2	22051.8	0.0
Off-Road	Misc. Equipment	0.6	0.6	42.0	0.3	107.8	0.1
	Sub-Total	0.6	0.6	42.0	0.3	107.8	0.1
	Total Emissions from Park (lbs/month)	48,743.9	30,906.2	56,723.8	6,266.6	180,579.6	185.3
	Total Emissions from Park (tons/day)	0.81	0.52	0.95	0.10	3.01	0.00
	Total Annual Tons of Emissions (Winter plus Summer)	341	207	428	63	1,770	2

Table 1.4: Summary of Wintertime Percentages

		TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
Camping	Watchman	0.87%	1.36%	4.91%	0.89%	1.70%	11.85%
	South	0.65%	1.03%	3.72%	0.38%	1.29%	1.99%
	Lava Point	0.04%	0.06%	0.22%	0.02%	0.08%	0.12%
	Back Country	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	1.56%	2.46%	**8.85%**	1.29%	3.07%	13.96%
Facilities	Zion Lodge	0.06%	0.09%	0.01%	0.76%	0.00%	13.18%
	Old Visitor Center	0.00%	0.00%	0.00%	0.19%	0.00%	4.47%
	Maintenance Yard	0.00%	0.00%	0.09%	0.03%	0.00%	2.14%
	Shuttle Bus Maintenance Yard	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Watchman Bone Yard	0.99%	1.57%	5.65%	0.58%	1.96%	3.02%
	Grotto House	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Environmental Education Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Kolob Canyon Visitor Center	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	East/South/New Walk Entrances	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Rockville Sewage Treatment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Park Landfill	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	1.05%	1.66%	5.75%	1.55%	1.96%	22.81%
Residential	Oak Creek	0.12%	0.19%	0.18%	0.18%	0.24%	2.65%
	Watchman	0.10%	0.16%	0.15%	0.19%	0.21%	3.14%
	Kolob Canyon	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Pine Creek	0.04%	0.06%	0.06%	0.03%	0.08%	0.13%
	East Entrance	0.05%	0.08%	0.07%	0.04%	0.10%	0.17%
	Lava Point	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Firepit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	0.31%	0.49%	0.46%	0.43%	0.63%	6.09%
Evaporative	Solvent Use	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
Road Maintenance	Paving	0.00%	0.00%	58.74%	0.00%	0.00%	0.00%
	Sub-Total	0.00%	0.00%	58.74%	0.00%	0.00%	0.00%
Other Area	Cinder Piles	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Prescribed Burning	77.01%	**88.85%**	22.50%	67.53%	82.07%	57.09%
	Wildfires	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Reintrained Dust, Tire, & Brake Wea	19.97%	6.40%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	96.99%	95.25%	22.50%	67.53%	82.07%	57.09%
On-Road	Visitor Passenger Vehicles	0.07%	0.10%	3.12%	23.93%	11.10%	0.00%
	Tour Buses	0.01%	0.02%	0.08%	1.30%	0.10%	0.00%
	Government Vehicles	0.01%	0.02%	0.37%	3.97%	1.01%	0.00%
	Shuttle Buses	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sub-Total	0.09%	0.14%	3.58%	29.19%	12.21%	0.00%
Off-Road	Misc. Equipment	0.00%	0.00%	0.07%	0.01%	0.06%	0.05%
	Sub-Total	0.00%	0.00%	0.07%	0.01%	0.06%	0.05%
	Total Emissions from Park	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 1.5: Comparison of Zion National Park Emissions with Surrounding Counties

Region	Comment	Annual Emissions in Tons per Year TSP	PM10	VOC	NOx	CO
Zion Park	Wildfires Included	341	207	428	63	1,770
Zion Park	Wildfires Not Included	219	122	336	34	764
Washington County	Contains most of Zion Park	no value	3,640	20,759	3,234	33,300
Kane County	Contains some of Zion Park	no value	544	6,041	412	3,941
Iron County	Contains tiny part of Zion Park	no value	2,411	12,053	3,437	21,439
State of Utah	Statewide Totals	no value	139,147	500,358	201,977	913,739

Table 3.1: Emissions from Campgrounds

Campground	N Latitude	Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Watchman	37°11.770'	112°59.312'	3897	Summer	169	A&B Lps	Yes	50.0%	100.0%	Pine	15

General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	657.8	34.6	657.8	229.0	4,353.9	2.6	49.4	252.6	4,802.6	0.4	7.6

No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use
100	2	2	10.0%

RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	2.4	0.4	2.4	0.3	1.8	14	84	1.4	8.4	10	60
Generator	0.16	0.1	0.16	0.1	6.2	3.7	0.02	0.0	16.91	10.1		0.0

Campground Totals	Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		660.3	660.3	4,359.4	133.4	4,821.1	67.6

Campground	N Latitude	Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Watchman	37°11.770'	112°59.312'	3897	Winter	169	A&B Lps	Yes	80.0%	40.0%	Pine	15

General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	421.0	34.6	421.0	229.0	2,786.5	2.6	31.6	252.6	3,073.6	0.4	4.9

No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use
19	3	2	0.0%

RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	0.684	0.4	0.684	0.3	0.513	14	23.94	1.4	2.394	10	17.1
Generator	0.16	0.0	0.16	0.0	6.2	0.0	3.7	0.0	16.91	0.0		0.0

Campground Totals	Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		421.7	421.7	2,787.0	55.6	3,076.0	22.0

Campground	N Latitude	W Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
South	37°12.172'	112°59.130'	4030	Summer	128	No	Yes	50.0%	100.0%	Pine	15

General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	498.2	34.6	498.2	229.0	3,297.6	2.6	37.4	252.6	3,637.4	0.4	5.8

No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use
0	2	2	100.0%

RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	0	0.4	0	0.3	0	14	0	1.4	0	10	0
Generator	0.16	0.0	0.16	0.0	6.2	0.0	3.7	0.0	16.91	0.0		0.0

Campground Totals	Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		498.2	498.2	3,297.6	37.4	3,637.4	5.8

Campground	N Latitude	Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
South	37°12.172'	112°59.130'	4030	Winter	128	No	Yes	80.0%	40.0%	Pine	15

General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	318.9	34.6	318.9	229.0	2,110.5	2.6	24.0	252.6	2,328.0	0.4	3.7

No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use
0	3	2	100.0%

RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	0	0.4	0	0.3	0	14	0	1.4	0	10	0
Generator	0.16	0.0	0.16	0.0	6.2	0.0	3.7	0.0	16.91	0.0		0.0

Campground Totals	Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		318.9	318.9	2,110.5	24.0	2,328.0	3.7

Table 3.1: Emissions from Campgrounds, Cont.

Campground		N Latitude	W Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Lava Point					Summer	6	No	Yes	#####	100.0%	Pine	15
General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	46.7	34.6	46.7	229.0	309.2	2.6	3.5	252.6	341.0	0.4	0.5
No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use									
0	2	2	100.0%									
RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	0	0.4	0	0.3	0	14	0	1.4	0	10	0
Generator	0.16	0.0	0.16	0.0	6.2	0.0	3.7	0.0	16.91	0.0		0.0
Campground Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		46.7		46.7		309.2		3.5		341.0		0.5

Campground		N Latitude	W Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Lava Point					Winter	6	No	Yes	#####	40.0%	Pine	15
General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	18.7	34.6	18.7	229.0	123.7	2.6	1.4	252.6	136.4	0.4	0.2
No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use									
0	3	2	100.0%									
RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	0	0.4	0	0.3	0	14	0	1.4	0	10	0
Generator	0.16	0.0	0.16	0.0	6.2	0.0	3.7	0.0	16.91	0.0		0.0
Campground Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		18.7		18.7		123.7		1.4		136.4		0.2

Campground		N Latitude	W Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Back Country					Summer	12	No	No	0.0%	100.0%	Pine	15
General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	0.0	34.6	0.0	229.0	0.0	2.6	0.0	252.6	0.0	0.4	0.0
No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use									
0	2	2	100.0%									
RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	0	0.4	0	0.3	0	14	0	1.4	0	10	0
Generator	0.16	0.0	0.16	0.0	6.2	0.0	3.7	0.0	16.91	0.0		0.0
Campground Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Campground		N Latitude	W Longditude	Elevation (ft)	Season	No. Campsites	Electrified	Campfires	% with Fires	% Occupancy	Wood Type	Wood/Fire (lbs)
Back Country		0.000	0.000	0	Winter	12	No	No	0.0%	40.0%	Pine	15
General Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
	34.6	0.0	34.6	0.0	229.0	0.0	2.6	0.0	252.6	0.0	0.4	0.0
No. RVs/day	Fuel Use (gal/day)	Fuel Use (gal/day)	% Gen. in Use									
0	3	2	100.0%									
RV Sites	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Propane	0.4	0	0.4	0	0.3	0	14	0	1.4	0	10	0
Generator	0.16	0.0	0.16	0.0	6.2	0.0	3.7	0.0	16.91	0.0		0.0
Campground Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Table 3.2: Emissions from Zion Lodge

Lodge	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Zion Lodge	37°15.113'	112°57.373'	4278	Summer	Oil Boiler	None	2673	Propane	None	7298	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	2.0	5.3	2.0	5.3	0.3	0.9	24.0	64.2	5.0	13.4	4.71	12.6
Unit 2	0.4	2.9	0.4	2.9	0.3	2.2	14.0	102.2	1.9	13.9	10	73.0

Energy Unit 3	Control	Fuel Use (gal/month)	Energy Unit 4	Control	Fuel Use (gal/month)
None	None	0	None	None	0

Heating	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 3		0.0		0.0		0.0		0.0		0.0		0.0
Unit 4		0.0		0.0		0.0		0.0		0.0		0.0

Heating Totals	Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		8.3	8.3	3.1	166.3	27.2	85.6

Campground	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Zion Lodge	37°15.113'	112°57.373'	4278	Winter	Oil Boiler	None	763	Propane	None	2083	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	2.0	1.5	2.0	1.5	0.3	0.3	24.0	18.3	5.0	3.8	4.71	3.6
Unit 2	0.4	0.8	0.4	0.8	0.3	0.6	14.0	29.2	1.9	4.0	10	20.8

Energy Unit 3	Control	Fuel Use (gal/month)	Energy Unit 4	Control	Fuel Use (gal/month)
None	None	0	None	None	0

Heating	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 3		0.0		0.0		0.0		0.0		0.0		0.0
Unit 4		0.0		0.0		0.0		0.0		0.0		0.0

Heating Totals	Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		2.4	2.4	0.9	47.5	7.8	24.4

Food Preparation	N Latitude	W Longditude	Elevation (ft)	Season	Lowfat Meat Grilled (lbs/month)	Highfat Meat Grilled (lbs/month)	Control	Meat Broiled (lbs/month)	Meat Broiled (lbs/month)	Control	
Zion Lodge Rest.	37°15.113'	112°57.373'	4278	Summer	0	4,093.0	Metalbestos F	7.0	2,301.0	Metalbestos Filter	
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
LwFt Grilled		0.0		0.0		0.0						
HiFt Grilled	5.0	20.5	5.0	20.5	0.2	0.8						
LwFt Broiled	2.0	0.0	2.0	0.0	0.3	0.0						
Hi Ft Broiled	32.0	73.6	32.0	73.6	3.8	8.7						

Food Prep. Totals	Summer	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		94.1	94.1	9.6	0.0	0.0	0.0

Food Preparation	N Latitude	W Longditude	Elevation (ft)	Season	Lowfat Meat Grilled (lbs/month)	Highfat Meat Grilled (lbs/month)	Control	Lowfat Meat Broiled (lbs/month)	Highfat Meat Broiled (lbs/month)	Control	
Zion Lodge Rest.	37°15.113'	112°57.373'	4278	Winter	0	1,184.0	Metalbestos F	2.0	657.0	Metalbestos Filter	
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
LwFt Grilled		0.0		0.0		0.0						
HiFt Grilled	5.0	5.9	5.0	5.9	0.2	0.2						
LwFt Broiled	2.0	0.0	2.0	0.0	0.3	0.0						
Hi Ft Broiled	32.0	21.0	32.0	21.0	3.8	2.5						

Food Prep. Totals	Winter	TSP (lbs/month)	PM10 (lbs/month)	VOC (lbs/month)	NOX (lbs/month)	CO (lbs/month)	SOx (lbs/month)
		26.9	26.9	2.7	0.0	0.0	0.0

Table 3.3: Emissions from Facilities

Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Headquarters/Old Cente	37°11.987'	112°59.205	3925	Summer	PropaneHt	None	266	Prop.Gen.	None	1.3	
Energy Unit	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.1	0.4	0.1	0.3	0.1	14.0	3.7	1.9	0.5	10.0	2.7
Unit 2	0.6	0.0	0.6	0.0	0.2	0.0	29.3	0.0	7.5	0.0	0.3	0.0
Energy Unit 3	Control	Fuel Use (gal/month)	Energy Unit 4	Control	Fuel Use (gal/month)							
None	None	0	None	None	0							
Energy Unit	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 3		0.0		0.0		0.0		0.0		0.0		0.0
Unit 4		0.0		0.0		0.0		0.0		0.0		0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.1		0.1		0.1		3.8		0.5		2.7
Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)		
Headquarters/Old Cente	37°11.987'	112°59.205	3925	Winter	PropaneHt	None	828	Prop.Gen.	None	1.3		
Energy Unit	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.3	0.4	0.3	0.3	0.2	14.0	11.6	1.9	1.6	10.0	8.3
Unit 2	0.6	0.0	0.6	0.0	0.2	0.0	29.3	0.0	7.5	0.0	0.3	0.0
Energy Unit 3	Control	Fuel Use (gal/month)	Energy Unit 4	Control	Fuel Use (gal/month)							
None	None	0	None	None	0							
Energy Unit	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 3		0.0		0.0		0.0		0.0		0.0		0.0
Unit 4		0.0		0.0		0.0		0.0		0.0		0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.3		0.3		0.2		11.6		1.6		8.3
Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)		
Maintenance Yard	37°12.678'	112°59.369	4035	Summer	PropaneHt	None	358	Waste Oil	None	4		
Energy Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.1	0.4	0.1	0.3	0.1	14.0	5.0	1.9	0.7	10.0	3.6
Unit 2	8.4	0.0	8.4	0.0	1.0	0.0	11.0	0.0	1.7	0.0	200.0	0.8
Gasoline Refueled (gal/month)	Control	Gasoline Loaded (gal/month)	Control	Diesel Loaded (gal/month)	Control	Parts Degreasing (gal/month)	Control					
3602	None	3602	None	837	None	0.58	WaterBase					
Evaporation	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Gasoline Ref.	n/a	n/a	n/a	n/a	12.7	45.7	n/a	n/a	n/a	n/a	n/a	n/a
Gasoline Load	n/a	n/a	n/a	n/a	11.5	41.4	n/a	n/a	n/a	n/a	n/a	n/a
Diesel Load.	n/a	n/a	n/a	n/a	0.03	0.0	n/a	n/a	n/a	n/a	n/a	n/a
Parts Degreas	n/a	n/a	n/a	n/a	0.1	0.0	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.2		0.2		87.3		5.1		0.7		4.4
Campground	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)		
Maintenance Yard	37°12.678'	112°59.369	4035	Winter	PropaneHt	None	117	Waste Oil	None	14		
Energy Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	1.6	1.9	0.2	10.0	1.2
Unit 2	8.4	0.1	8.4	0.1	1.0	0.0	11.0	0.2	1.7	0.0	200.0	2.8
Gasoline Refueled (gal/month)	Control	Gasoline Loaded (gal/month)	Control	Diesel Loaded (gal/month)	Control	Parts Degreasing (gal/month)	Control					
2158	None	2158	None	815	0	0.58	WaterBase					
Evaporation	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Gasoline Ref.	n/a	n/a	n/a	n/a	12.7	27.4	n/a	n/a	n/a	n/a	n/a	n/a
Gasoline Load	n/a	n/a	n/a	n/a	11.5	24.8	n/a	n/a	n/a	n/a	n/a	n/a
Diesel Load.	n/a	n/a	n/a	n/a	0.03	0.0	n/a	n/a	n/a	n/a	n/a	n/a
Parts Degreas	n/a	n/a	n/a	n/a	0.1	0.0	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.2		0.2		52.3		1.8		0.2		4.0

Table 3.3: Emissions from Facilities, Cont.

Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Watchman Bone Yard	37°11.678'	112°59.076	3985	Summer							
Energy Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1												
Unit 2												
Burn Pile (tons/month)	Materials											
10	Misc. trimmings											
Activity	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Burn Pile	34.6	346.0	34.6	346.0	229.0	2,290.0	2.6	26.0	252.6	2,526.0	0.4	4.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		346.0		346.0		2,290.0		26.0		2,526.0		4.0

Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Watchman Bone Yard	37°11.678'	112°59.076	3985	Winter							
Energy Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	Season	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1												
Unit 2												
Burn Pile (tons/month)	Materials											
14	Misc. trimmings											
Activity	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Burn Pile	34.6	484.4	34.6	484.4	229.0	3,206.0	2.6	36.4	252.6	3,536.4	0.4	5.6
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		484.4		484.4		3,206.0		36.4		3,536.4		5.6

Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Shuttle Bus Maintenance				Summer							
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1												
Unit 2												
Propan Refueled (gal/month)	Control	Propane Loaded (gal/month)	Control									
21,171.0	None	21,171.0	None									
Evaporation	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Prop. Bus Ref	n/a	n/a	n/a	n/a	3	140.02	n/a	n/a	n/a	n/a	n/a	n/a
rop.Tank Load	n/a	n/a	n/a	n/a	17	793.46	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		933.5		0.0		0.0		0.0

Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
huttle Bus Maintenance	0.000	0.000	0	Winter							
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1												
Unit 2												
Propan Refueled (gal/month)	Control	Propane Loaded (gal/month)	Control									
0.0	None	0.0	None									
Evaporation	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Prop. Bus Ref	n/a	n/a	n/a	n/a	3	0.00	n/a	n/a	n/a	n/a	n/a	n/a
rop.Tank Load	n/a	n/a	n/a	n/a	17	0.00	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Table 3.3: Emissions from Facilities, Cont.

Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Wood Used (Tons/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Grotto House	37°15.547'	112°57.081'	4533	Summer	Wood Stove	New	0.04				

Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	30.6	1.2	30.6	1.2	53	2.1	2.8	0.1	231	9.2	0.4	0.0
Unit 2												

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		1.2		1.2		2.1		0.1		9.2		0.0

Facility	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Wood Used (Tons/month)	Energy Unit 2	Control	Fuel Use (gal/month)	
Grotto House	37°15.547'	112°57.081'	4533	Winter	Wood Stove	New	0				

Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Unit 2												

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Table 3.4: Emissions from Residential Units

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Oak Creek Housing	37°12.692'	112°59.365'	4035	Summer	Propane Ht	None	132	Wood Stove	New	0.6	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.1	0.4	0.1	0.3	0.0	14.0	1.8	1.9	0.3	10.0	1.3
Unit 2	30.6	18.4	30.6	18.4	53	31.8	2.8	1.7	231	138.6	0.4	0.2
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		18.4		18.4		31.8		3.5		138.9		1.6

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Oak Creek Housing	37°12.692'	112°59.365'	4035	Winter	Propane Ht	None	415	Wood Stove	New	1.9	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.2	0.4	0.2	0.3	0.1	14.0	5.8	1.9	0.8	10.0	4.2
Unit 2	30.6	58.1	30.6	58.1	53	100.7	2.8	5.3	231	438.9	0.4	0.8
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		58.3		58.3		100.8		11.1		439.7		4.9

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Watchman Housing	37°12.222'	112°58.782'	4013	Summer	Propane Ht	None	165	Wood Stove	New	0.5	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.1	0.4	0.1	0.3	0.0	14.0	2.3	1.9	0.3	10.0	1.7
Unit 2	30.6	15.3	30.6	15.3	53	26.5	2.8	1.4	231	115.5	0.4	0.2
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		15.4		15.4		26.5		3.7		115.8		1.9

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Watchman Housing	37°12.222'	112°58.782'	4013	Winter	Propane Ht	None	518	Wood Stove	New	1.6	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.2	0.4	0.2	0.3	0.2	14.0	7.3	1.9	1.0	10.0	5.2
Unit 2	30.6	49.0	30.6	49.0	53	84.8	2.8	4.5	231	369.6	0.4	0.6
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		49.2		49.2		85.0		11.7		370.6		5.8

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Kolob Canyon				Summer	Propane Ht	None	20	Wood Stove	New	0.04	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.008	0.4	0.0	0.3	0.0	14	0.3	1.9	0.0	10	0.2
Unit 2	30.6	1.2	30.6	1.2	53	2.1	2.8	0.1	231	9.2	0.4	0.0
Totals	Summer (lbs/month)	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		1.2		1.2		2.1		0.4		9.3		0.2

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Kolob Canyon				Winter	Propane Ht	None	0	Wood Stove	New	0	
Heating Units	TSP Factor (lbs/month)	TSP	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor (lbs/month)	CO	SOx Factor (lbs/month)	SOx
Unit 1	0.4	0.000	0.4	0.0	0.3	0.0	14	0.0	1.9	0.0	10	0.0
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Table 3.4: Emissions from Residential Units, Cont.

Residential Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Pine Creek Surperintend				Summer	Electric Ht	None	0	Wood Stove	New	0.2	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	6.1	30.6	6.1	53	10.6	2.8	0.6	231	46.2	0.4	0.1
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		6.1		6.1		10.6		0.6		46.2		0.1

Residential Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Pine Creek Surperintend	0.000	0.000	0	Winter	Electric Ht	None	0	Wood Stove	New	0.6	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	18.4	30.6	18.4	53	31.8	2.8	1.7	231	138.6	0.4	0.2
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		18.4		18.4		31.8		1.7		138.6		0.2

Residential Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
East Entrance Housing				Summer	Propane Ht	None	17	Wood Stove	New	0.2	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.2	1.9	0.0	10.0	0.2
Unit 2	30.6	6.1	30.6	6.1	53	10.6	2.8	0.6	231	46.2	0.4	0.1
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		6.1		6.1		10.6		0.8		46.2		0.3

Residential Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
East Entrance Housing	0.000	0.000	0	Winter	Propane Ht	None	0	Wood Stove	New	0.8	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	24.5	30.6	24.5	53	42.4	2.8	2.2	231	184.8	0.4	0.3
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		24.5		24.5		42.4		2.2		184.8		0.3

Residential Area		N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Lava Point Housing (1 u					Summer	Propane Ht	None	1.9	Wood Stove	New	0	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Residential Area		N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Lava Point Housing (1 u		0.000	0.000	0	Winter	Propane Ht	None	0	Wood Stove	New	0	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Table 3.4: Emissions from Residential Units, Cont.

Residential Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Firepit (1 unit)				Summer	Propane H	None	20				
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.3	1.9	0.0	10.0	0.2
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.3		0.0		0.2

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
Firepit (1 unit)	0.000	0.000	0	Winter	Propane H	None	0				
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Residential Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
				Summer	Propane Ht	None		Wood Stov New			
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Residential Area	N Latitude	Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
0	0.000	0.000	0	Winter	Propane Ht	None	0	Wood Stov New		0.8	
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	24.5	30.6	24.5	53	42.4	2.8	2.2	231	184.8	0.4	0.3
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		24.5		24.5		42.4		2.2		184.8		0.3

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
				Summer	Propane Ht	None		Wood Stove New			
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Residential Area	N Latitude	W Longditude	Elevation (ft)	Season	Energy Unit 1	Control	Fuel Use (gal/month)	Energy Unit 2	Control	Wood Use (Tons/month)	
0	0.000	0.000	0	Winter	Propane Ht	None		Wood Stove New			
Heating Units	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Unit 1	0.4	0.0	0.4	0.0	0.3	0.0	14.0	0.0	1.9	0.0	10.0	0.0
Unit 2	30.6	0.0	30.6	0.0	53	0.0	2.8	0.0	231	0.0	0.4	0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		0.0		0.0		0.0		0.0		0.0		0.0

Table 4.1: Emissions from Solvent Usage

Solvent Usage

Name of Material	Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
Summer				
Acrylic Latex Paint	145	1.29	8.3%	10.9
Mineral Spirits	2	0.83	72.0%	0.8
Gasoline	1	0.72	100.0%	0.5
Sundance Pipeline #4 Neutral Floor Clnr	50	1.03	30.0%	10.9
Command Center 2 LOOK Glass Cleaner Concentrate	3	0.99	93.0%	1.9
Command Center 22 Speedball 2000 Power Cleaner Conc.	3	1	80.0%	1.7
Blue Skies Disinfectant Cleaner	2	1.01	88.0%	1.2
Command Center 19 Triple Team heavy Duty Washroom Cleaner	1.5	1.05	56.0%	0.6
Simple Green	7	1.0257	0.8%	0.0
Zeptox	0.6	0.795	100.0%	0.3
Sub-Total				29.0

Name of Material	Amount (gals/year)	Specific Gravity	% Volatile Content (by weight)	VOC (lbs/month)
Winter				
Acrylic Latex Paint	145	1.29	8.3%	10.9
Mineral Spirits	2	0.83	72.0%	0.8
Gasoline	1	0.72	100.0%	0.5
Sundance Pipeline #4 Neutral Floor Clnr	50	1.03	30.0%	10.9
Command Center 2 LOOK Glass Cleaner Concentrate	3	0.99	93.0%	1.9
Command Center 22 Speedball 2000 Power Cleaner Conc.	3	1	80.0%	1.7
Blue Skies Disinfectant Cleaner	2	1.01	88.0%	1.2
Command Center 19 Triple Team heavy Duty Washroom Cleaner	1.5	1.05	56.0%	0.6
Simple Green	7	1.0257	0.8%	0.0
Zeptox	0.6	0.795	100.0%	0.3
Sub-Total				29.0

Table 4.2: Emissions from Road Paving

Road Paving

Name of Material	Amount (tons/month)	VOC Factor	VOC (lbs/month)
Summer			
Asphalt Paving	83.3	0.2	33,320.0
Sub-Total			33,320.0
Name of Material	Amount (gals/year)	VOC Factor	VOC (lbs/month)
Winter			
Asphalt Paving	83.3	0.2	33,320.0
Sub-Total			33,320.0

Table 4.3: Emissions from Other Area Sources

Item	N Latitude	W Longditude	Elevation (ft)	Season	Pile Surface Area (sqft)	Pile Number						
Cinder Piles	37°12.106'	112°58.957'	3856	Summer	100	3						
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Cinder Piles	3.5	0.7	1.7	0.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Summer TSP (lbs/month)			PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
	0.7			0.4								

Item	N Latitude	W Longditude	Elevation (ft)	Season	Pile Surface Area (sqft)	Pile Number						
Cinder Piles	37°12.106'	112°58.957'	3856	Winter	100	3						
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Cinder Piles	3.5	0.7	1.7	0.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
	0.7			0.4								

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month	Type Burning	Tons/Acre Burned	Acres Burned per Month	
Prescribed Burning				Summer	Grass/Brush	2	0	General	10.5	29	
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Grass/Brush	20	0.0	20	0.0	6.9	0.0	4	0.0	150	0.0	0.1	0.0
General	35.6	10,840.2	26	7,917.0	12.1	3,684.5	4	1,218.0	140	42,630.0	0.1	30.5
Totals	Summer TSP (lbs/month)			PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
	10,840.2			7,917.0		3,684.5		1,218.0		42,630.0		30.5

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month	Type Burning	Tons/Acre Burned	Acres Burned per Month	
Prescribed Burning	0.000	0.000	0	Winter	Grass/Brush	2	4	General	10.5	100	
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Grass/Brush	20	160.0	20	160.0	6.9	55.2	4	32.0	150	1,200.0	0.1	0.8
General	35.6	37,380.0	26	27,300.0	12.1	12,705.0	4	4,200.0	140	147,000.0	0.1	105.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
	37,540.0			27,460.0		12,760.2		4,232.0		148,200.0		105.8

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month				
Wildfires				Summer	General	18	114				
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
General	17	34,884.0	11.9	24,418.8	12.7	26,060.4	4	8,208.0	140	287,280.0	0.1	205.2
Totals	Summer TSP (lbs/month)			PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
	34,884.0			24,418.8		26,060.4		8,208.0		287,280.0		205.2

Item	N Latitude	W Longditude	Elevation (ft)	Season	Type Burning	Tons/Acre Burned	Acres Burned per Month				
Wildfires	0.000	0.000	0	Winter	General	18	0				
	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
General	17	0.0	11.9	0.0	12.7	0.0	4	0.0	140	0.0	0.1	0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
	0.0			0.0		0.0		0.0		0.0		0.0

Table 5.17: Summary of Emissions from On-Road Mobile Sources

Item	Season	Visitor Miles per Month	Tour Bus Miles per Month	Government Miles per Month	Shuttle Miles per Month	Total Miles
On-Road Mobile	Summer	839,968	11,321	86,125	54,810	992,224

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Visitor Vehicles	0.025	46.3	0.025	46.3	3.26	6,036.9	1	1,851.8	16.9	31,295.6		0.0
Tour Buses	0.65	16.2	0.65	16.2	5.4	134.8	9.31	232.4	20.9	521.6		0.0
Government Vehicles	0.083	15.8	0.083	15.8	3.09	586.7	1.56	296.2	16.24	3,083.5		0.0
Shuttle Buses	0.056	6.8	0.056	6.8	3.44	415.7	9.85	1,190.2	0.3	36.3		0.0
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		85.0		85.0		7,174.1		3,570.6		34,937.1		0.0

Item	Season	Visitor Miles per Month	Tour Bus Miles per Monts	Government Miles per Month	Shuttle Miles per Month	Total Miles
On-Road Mobile	Winter	586,355	3,956	56,361	0	646,672

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Visitor Vehicles	0.025	32.3	0.025	32.3	1.37	1,771.0	1.16	1,499.5	15.5	20,036.7		0.0
Tour Buses	0.65	5.7	0.65	5.7	5.4	47.1	9.31	81.2	20.9	182.3		0.0
Government Vehicles	0.054	6.7	0.054	6.7	1.7	211.2	2	248.5	14.75	1,832.8		0.0
Shuttle Buses	0.056	0.0	0.056	0.0	3.44	0.0	9.85	0.0	0.3	0.0		0.0
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		44.7		44.7		2,029.3		1,8292		22,051.8		0.0

Item	N Latitude	W Longditude	Elevation (ft)	Season	Miles of Paved Road	Miles Driven on Paved per Month	Miles of Unpaved Road	Miles Drinve on Unpaved per Month
Reintrained Road Dust				Summer	39.7	992,224	14	104.0

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Paved Roads	6.8	14,861.5	1.4	3,016.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unpaved Roads	779.0	178.4	280.0	64.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Summer	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		15,040.0		3,080.2								

Item	N Latitude	W Longditude	Elevation (ft)	Season	Mles of Paved Road	Mle: Driven on Paved per Month	Miles of Unpaved Road	Miles Drinve on Unpaved per Month
Reintrained Road Dust	0.000	0.000	0	Winter	39.7	646,672	14	30.0

	TSP Factor	TSP (lbs/month)	PM10 Factor	PM10 (lbs/month)	VOC Factor	VOC (lbs/month)	NOx Factor	NOX (lbs/month)	CO Factor	CO (lbs/month)	SOx Factor	SOx (lbs/month)
Paved Roads	6.8	9,685.8	1.4	1,965.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unpaved Roads	731	48.3	169.0	11.2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Totals	Winter	TSP (lbs/month)		PM10 (lbs/month)		VOC (lbs/month)		NOX (lbs/month)		CO (lbs/month)		SOx (lbs/month)
		9,734.1		1,976.8								

Table 5.18: Emissions from Off-Road Mobile Sources

Item	Season	Num ber of Chainsaws	Average Use (hours/m onth)	Num ber of W eed W ack.	Average Use (hours/m onth)	Num ber of Lawnm owers	Average Use (hours/m onth)	Num ber of Pw. W heelbarrows	Average Use (hours/m onth)	Num ber of Com pressors	Average Use (hours/m onth)
Small Off-Road Equipment	Summer	10	8.3	6	2.5	1	6.7	1	2.5	1	

	TSP Factor	TSP (lbs/m onth)	PM10 Factor	PM10 (lbs/m onth)	VOC Factor	VOC (lbs/m onth)	NOx Factor	NOX (lbs/m onth)	CO Factor	CO (lbs/m onth)	SOx Factor	SOx (lbs/m onth)
Chainsaws	22.5	0.4	22.5	0.4	922.11	16.9	3.59	0.1	2726.3	49.8	1.8	0.0
W eed W ackers	22.5	0.1	22.5	0.1	922.11	5.1	3.59	0.0	2726.3	15.0	1.8	0.0
Law nm ower	1.87	0.0	1.87	0.0	100.55	1.5	11.91	0.2	2093.28	30.9	2.37	0.0
Powered W heelbarrow	1.87	0.0	1.87	0.0	100.55	0.6	11.91	0.1	2093.28	11.5	2.37	0.0
Com pressor	0.16	0.0	0.16	0.0	6.2	0.0	0.02	0.0	17	0.0		0.0
Totals	Summer	TSP (lbs/m onth)		PM10 (lbs/m onth)		VOC (lbs/m onth)		NOX (lbs/m onth)		CO (lbs/m onth)		SOx (lbs/m onth)
		0.6		0.6		24.0		0.3		107.3		0.1

Item	Season	Num ber of Chainsaws	Average Use (hours/m onth)	Num ber of W eed W ack.	Average Use (hours/m onth)	Num ber of Lawnm owers	Average Use (hours/m onth)	Num ber of Pw. W heelbarrows	Average Use (hours/m onth)	Num ber of Com pressors	Average Use (hours/m onth)
Small Off-Road Equipment	W inter	10	8.3	6	2.5	1	6.7	1	2.5	1	

	TSP Factor	TSP (lbs/m onth)	PM10 Factor	PM10 (lbs/m onth)	VOC Factor	VOC (lbs/m onth)	NOx Factor	NOX (lbs/m onth)	CO Factor	CO (lbs/m onth)	SOx Factor	SOx (lbs/m onth)
Chainsaws	22.5	0.4	22.5	0.4	922.11	16.9	3.59	0.1	2726.3	49.8	1.8	0.0
W eed W ackers	22.5	0.1	22.5	0.1	922.11	5.1	3.59	0.0	2726.3	15.0	1.8	0.0
Law nm ower	1.87	0.0	1.87	0.0	100.55	1.5	11.91	0.2	2093.28	30.9	2.37	0.0
Powered W heelbarrow	1.87	0.0	1.87	0.0	100.55	0.6	11.91	0.1	2093.28	11.5	2.37	0.0
Com pressor	0.16	0.0	0.16	0.0	6.2	0.0	0.02	0.0	17	0.0		0.0
Totals	W inter	TSP (lbs/m onth)		PM10 (lbs/m onth)		VOC (lbs/m onth)		NOX (lbs/m onth)		CO (lbs/m onth)		SOx (lbs/m onth)
		0.6		0.6		24.0		0.3		107.3		0.1

Item	Season	Num ber of. S=erb-.f.	Average Use (hours/m onth)	Numberof All Terrain	Average Use (hours/m onth)	Num ber of John Deer	Average Use (hours/m onth)	Num ber of F ront Loader	Average Use (hoursm onth)		
Large Off-Road Equipment	Summer	2	2.5	2	16.7	1		1			

	TSP Factor	TSP (lbs/m onth)	PM10 Factor	PM10 (lbs/m onth)	VOC Factor	VOC (lbs/m onth)	NOx Factor	NOX (lbs/m onth)	CO Factor	CO (lbs/m onth)	SOx Factor	SOx (lbs/m onth)
Snow m obiles	0.07	0.0	0.07	0.0	4.68	0.0	0.01	0.0	11.9	0.1		0.0
All Terrai r c le	0.07	0.0	0.07	0.0	4.68	0.2	0.01	0.0	11.9	0.4		0.0
John Deer Tra t	8	0.0	8	0.0	125	0.0	151	0.0	32600	0.0	5.31	0.0
Front Loader	45.7	0.0	45.7	0.0	62.3	0.0	438.6	0.0	174.9	0.0	31.2	0.0
Totals	Summer	TSP (lbs/m onth)		PM10 (lbs/m onth)		VOC (lb./-%)		NOX (lb./month)		CO (lbs/m onth)		SOx (lbs/m onth)
		0.0		0.0		0.2		0.0		0.5		0.0

Item	Season	Num ber of Snowm obiles	Average Use (hours/m onth)	Num ber of All Terrain	Average Use I (hours/m onth)	Numb..f John Deer	Average Use I (hours/m onth)	Numb..f Front Loader	Average Use (ho../month)		
Large Off-Road Equipment	W inter	2	2.5	2	16.7	1		1			

	TSP Factor	TSP (lbs/m onth)	PM10 Factor	PM10 (lbs/m onth)	VOC Factor	VOC (lb./month)	NOx Factor	NOX (lb./month)	CO Factor	CO (lbs/m onth)	SOx Factor	SOx (lbs/m onth)
Snow m obiles	0.07	0.0	0.07	0.0	4.68	0.0	0.01	0.0	11.9	0.1		0.0
All Terrain Vehicle	0.07	0.0	0.07	0.0	4.68	0.2	0.01	0.0	11.9	0.4		0.0
John Deer Tractor	8	0.0	8	0.0	125	0.0	151	0.0	32600	0.0	5.31	0.0
Front Loader	45.7	0.0	45.7	0.0	62.3	0.0	438.6	0.0	174.9	0.0	31.2	0.0
0												
Totals	W inter	TSP (lbs/m onth)		10 (P onth)		VOC (lbs/m onth)		NOX (lbs/m onth)		CO (lbs/m onth)		SOx (lbs/m onth)
		0.0		0.0		0.2		0.0		0.5		0.0

Evaporation from Off-Road Devices

Off-Road Device	Number of Units	Hours per Month of Use	VOC Factor	VOC (lbs/month)
Summer				
Chainsaws	10	8.3		0.0
Snowmobiles	2	2.5	18	2.4
Weed Wackers	6	2.5	0.54	0.2
All Terrain Vehicles (6 wheel polaris)	2	16.7	18	2.4
Lawnmower	1	6.7	1.16	0.1
Powered Wheelbarrow	1	2.5	1.16	0.1
John Deer Tractor with Shovel	1		94.5	6.2
Compressor	1		3.38	0.2
Front Loader	1		94.5	6.2
Sub-Total				17.8

Name of Material	Number of Units	Hours per Month of Use	VOC Factor	VOC (lbs/month)
Winter				
Chainsaws	10	8.3		0.0
Snowmobiles	2	2.5	18	2.4
Weed Wackers	6	2.5	0.54	0.2
All Terrain Vehicles (6 wheel polaris)	2	16.7	18	2.4
Lawnmower	1	6.7	1.16	0.1
Powered Wheelbarrow	1	2.5	1.16	0.1
John Deer Tractor with Shovel	1		94.5	6.2
Compressor	1		3.38	0.2
Front Loader	1		94.5	6.2
Zeptox				
Sub-Total				17.8

Worksheet One

Apportionment by Visitation

1999 Visitor Totals

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	73048	73049	124528	219859	220499	300248	336872	375604	311015	239139	125886	71817	2471564

Monthly **Visitor Percentages**

	0.030	0.030	0.052	0.092	0.092	0.125	0.140	0.156	0.130	0.100	0.052	0.030	1.029
Seasonal Visitor Percentage April through October =						0.83							
Seasonal Visitor Percentage November thru March =						0.19							

Zion Lodge Small Boiler Monthly Fuel Usage Proportioned to Visitation (gallons)

	666	686	1169	2063	2069	2818	3161	3525	2919	2244	1181	674	23175
Seasonal Fuel Usage April through October =						19342	2763						
Seasonal Fuel Usage November through March =						4502	900						

Zion Lodge Monthly Propane Usage Proportion to Visitation (gallons)

	1818	1872	3191	5634	5650	7693	8632	9624	7969	6128	3226	1840	63276
Seasonal Fuel Usage April through October =						52813	7545						
Seasonal Fuel Usage November through March =						12291	2458						

Zion Lodge Monthly Meat Usage Proportioned to Visitation (lbs)

Type Cooker	Type Meat													
Grill	Beef	573	590	1006	1776	1782	2426	2722	3035	2513	1932	1017	580	19953
Seasonal Fuel Usage April through October =							16186	2312						
Seasonal Fuel Usage November through March =							3767	753						
Broiler	Beef	573	590	1006	1776	1782	2426	2722	3035	2513	1932	1017	580	19953
Seasonal Fuel Usage April through October =							16186	2312						
Seasonal Fuel Usage November through March =							3767	753						
Grill	Ham Products	431	444	757	1336	1340	1824	2047	2282	1890	1453	765	436	15005
Seasonal Fuel Usage April through October =							12172	1739						
Seasonal Fuel Usage November through March =							2833	567						
Grill	Pork Sausage	15	16	26	47	47	64	72	80	66	51	27	15	525
Seasonal Fuel Usage April through October =							426	61						
Seasonal Fuel Usage November through March =							99	20						
Broiler	Buffalo	2	2	3	5	6	8	8	9	8	6	3	2	62
Seasonal Fuel Usage April through October =							50	7						
Seasonal Fuel Usage November through March =							12	2						

NPS Maintenance Yard

Use	Material Type													
Water & Space Heating	Propane	89	91	156	275	276	375	421	469	389	299	157	90	3087
Seasonal Fuel Usage April through October =							2504	358						
Seasonal Fuel Usage November through March =							583	117						
Waste Oil Burning	Waste Oil	16	14	12	9	5	3	0	1	4	8	12	14	98
Seasonal Fuel Usage April through October =							30	4						
Seasonal Fuel Usage November through March =							68	14						
Refueling	Gasoline	2183	2132	2373	2874	3581	3645	3978	4330	3560	3245	2095	2009	36005
Seasonal Fuel Usage April through October =							25213	3602						
Seasonal Fuel Usage November through March =							10792	2158						
Refueling	Diesel	505	574	855	725	803	1111	915	790	686	826	823	1316	9929
Seasonal Fuel Usage April through October =							5856	837						
Seasonal Fuel Usage November through March =							4073	815						
Auto Parts Degreasing	Water Based Degreaser	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	6.96
Seasonal Fuel Usage April through October =							4.06	0.58						
Seasonal Fuel Usage November through March =							2.9	0.58						
Tank Loading	Gasoline	2183	2132	2373	2874	3581	3645	3978	4330	3560	3245	2095	2009	36005
Seasonal Fuel Usage April through October =							25213	3602						
Seasonal Fuel Usage November through March =							10792	2158						

Worksheet Two
Heating Months - Monthly Fuel Usage

Mean Temperature in $^{0}_{F}$

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
40.2	45	49.7	57.5	67.1	77.5	83.9	81.5	74.2	63.3	49.8	41.1	730.8

Low Monthly Average Temperature in $^{0}_{F}$

14.4	21	28.3	36.6	48.4	55	63.6	63.4	53.2	40.3	28.1	20.8	

Difference Between Average Low and 65 ^{0}F

50.6	44	36.7	28.4	16.6	10	1.4	1.6	11.8	24.7	36.9	44.2	306.9

Monthly Percentage of Total Annual Difference = Approximation of Proportion of Fuel Usage Per Month

0.16	0.14	0.12	0.09	0.05	0.03	0.00	0.01	0.04	0.08	0.12	0.14	1.00

ntage of Total Seasonal Difference (April through October) = Approximation of Proportion of Fuel Usage Per Month for Seaso

0.00	0.00	0.00	0.30	0.17	0.11	0.01	0.02	0.12	0.26	0.00	0.00	0.99

Seasonal Factor for April through October = 0.31 Seasonal Factor for November through March = 0.69

Oak Creek Residential Area (Year-Round)

Monthly Propane Usage in Gallons (based on 3000 gallons/year)

495	430	359	278	162	98	14	16	115	241	361	432	3000

Average Monthly Usage (April through October) = 132
Average Monthly Usage (November through March) = 415

Monthly Wood Usage in Tons (14 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

2.3	2.0	1.7	1.3	0.8	0.5	0.1	0.1	0.5	1.1	1.7	2.0	14

Average Monthly Usage (April through October) = 0.6
Average Monthly Usage (November through March) = 1.9

Watchman Residential Area (Year-Round)

Monthly Propane Usage in Gallons (based on 3744 gallons/year)

617	537	448	346	203	122	17	20	144	301	450	539	3744

Average Monthly Usage (April through October) = 165
Average Monthly Usage (November through March) = 518

Monthly Wood Usage in Tons (11.3 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

1.9	1.6	1.4	1.0	0.6	0.4	0.1	0.1	0.4	0.9	1.4	1.6	11

Average Monthly Usage (April through October) = 0.5
Average Monthly Usage (November through March) = 1.6

Pine Creek Supt. Housing Area (Year-Round)

Monthly Propane Usage in Gallons (based on 0 gallons/year)

0	0	0	0	0	0	0	0	0	0	0	0	0

Average Monthly Usage **(April through October)** = 0
Average Monthly Usage **(November through** March) = 0

Monthly Wood Usage in Tons (5.6 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

0.9	0.8	0.7	0.5	0.3	0.2	0.0	0.0	0.2	0.5	0.7	0.8	6

Average Monthly Usage **(April through October)** = 0.2
Average Monthly Usage **(November through March)** = 0.6

East Entrance Residential Area (2 houses: 1 seasonal, 1 **year-round)**

Monthly Propane Usage in **Gallons (based** on **120 gallons April through October)**

0	0	0	36	21	13	2	2	15	31	0	0	119

Average Monthly Usage **(April through October)** = 17
Average Monthly Usage **(November through March)** = 0

Monthly Wood Usage in Tons (5.6 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

0.9	0.8	0.7	0.5	0.3	0.2	0.0	0.0	0.2	0.5	0.7	0.8	6

Average Monthly Usage **(April through October)** = 0.2
Average Monthly Usage **(November through March)** = 0.8

Fire Pit Residence (Seasonal)

Monthly Propane Usage in **Gallons (based** on **140 gallons April through October)**

0	0	0	42	24	15	2	2	17	36	0	0	139

Average Monthly Usage **(April through October)** = 20
Average Monthly Usage **(November through** March) = 0

Monthly Wood Usage in Tons (0 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

0	0	0	0	0	0	0	0	0	0	0	0	0

Average Monthly Usage (April **through October)** = 0.0
Average Monthly Usage **(November through March)** = 0.0

Lava Point Residence (Seasonal)

Monthly Propane Usage in **Gallons (based** on **13.2 gallons April through October)**

0	0	0	3.9	2.3	1.4	0.2	0.2	1.6	3.4	0	0	13

Average Monthly Usage **(April through October)** = 1.9
Average Monthly Usage **(November through March)** = 0.0

Monthly Wood Usage in Tons (0 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

0	0	0	0	0	0	0	0	0	0	0	0	0

Average Monthly Usage (April **through October)** = 0.0
Average Monthly Usage **(November through March)** = 0.0

Kolob Canyon Residential Area (Seasonal)

Monthly Propane Usage in **Gallons (based** on **140 gallons April through October)**

0	0	0	42	24	15	2	2	17	36	0	0	139

Average Monthly Usage **(April through October)** = 19.9
Average Monthly Usage **(November through March)** = 0.0

Monthly Wood Usage in Tons (0.25 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2

Average Monthly Usage **(April through October)** = 0.04
Average Monthly Usage **(November through March)** = 0.0

Worksheet Two

Heating Months - Monthly Fuel Usage

Mean Temperature in $^{0}_{F}$

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
40.2	45	49.7	57.5	67.1	77.5	83.9	81.5	74.2	63.3	49.8	41.1	730.8

Low Monthly Average Temperature in $^{0}_{F}$

14.4	21	28.3	36.6	48.4	55	63.6	63.4	53.2	40.3	28.1	20.8	

Difference Between Average Low and 65 ^{0}F

50.6	44	36.7	28.4	16.6	10	1.4	1.6	11.8	24.7	36.9	44.2	306.9

Monthly Percentage of Total Annual Difference = Approximation of Proportion of Fuel Usage Per Month

0.16	0.14	0.12	0.09	0.05	0.03	0.00	0.01	0.04	0.08	0.12	0.14	1.00

ntage of Total Seasonal Difference (April through October) = Approximation of Proportion of Fuel Usage Per Month for Seas n

0.00	0.00	0.00	0.30	0.17	0.11	0.01	0.02	0.12	0.26	0.00	0.00	0.99

Seasonal Factor for April through October = 0.31 Seasonal Factor for November through March = 0.69

Oak Creek Residential Area (Year-Round)

Monthly Propane Usage in Gallons (based on 3000 gallons/year)

495	430	359	278	162	98	14	16	115	241	361	432	3000

Average Monthly Usage (April through October) = 132
Average Monthly Usage (November through March) = 415

Monthly Wood Usage in Tons (14 **tons/year - weight based on assumption of 50% Pinon and 50% Juniper)**

2.3	2.0	1.7	1.3	0.8	0.5	0.1	0.1	0.5	1.1	1.7	2.0	14

Average Monthly Usage (April through October) = 0.6
Average Monthly Usage (November through March) = 1.9

Watchman Residential Area (Year-Round)

Monthly Propane Usage in Gallons (based on 3744 gallons/year)

617	537	448	346	203	122	17	20	144	301	450	539	3744

Average Monthly Usage (April through October) = 165
Average Monthly Usage (November through March) = 518

Monthly Wood Usage in Tons (11.3 tons/year - weight based on assumption of 50% **Pinon and 50% Juniper)**

1.9	1.6	1.4	1.0	0.6	0.4	0.1	0.1	0.4	0.9	1.4	1.6	11

Average Monthly Usage (April through October) = 0.5
Average Monthly Usage (November through March) = 1.6

Pine Creek Supt. Housing Area (Year-Round)

Monthly Propane Usage in Gallons (based on 0 gallons/year)

0	0	0	0	0	0	0	0	0	0	0	0	0

Average Monthly Usage (April **through October) =** 0
Average Monthly Usage (November through March) = 0

Monthly Wood Usage in Tons (5.6 tons/year - weight based on assumption of 50% **Pinon and 50% Juniper)**

0.9	0.8	0.7	0.5	0.3	0.2	0.0	0.0	0.2	0.5	0.7	0.8	6

Average Monthly Usage (April through October) = 0.2
Average Monthly Usage (November through March) = 0.6

East Entrance Residential Area (2 **houses:** 1 **seasonal,** 1 **year-round)**

Monthly Propane Usage in Gallons (based on 120 gallons April through October)

0	0	0	36	21	13	2	2	15	31	0	0	119

Average Monthly Usage (April through October) = 17
Average Monthly Usage (November through March) = 0

Monthly Wood Usage in Tons (5.6 tons/year - weight based on assumption of 50% **Pinon and 50% Juniper)**

0.9	0.8	0.7	0.5	0.3	0.2	0.0	0.0	0.2	0.5	0.7	0.8	6

Average Monthly Usage (April through October) = 0.2
Average Monthly Usage (November through March) = 0.8

Fire Pit Residence (Seasonal)

Monthly Propane Usage in Gallons (based on 140 gallons April through October)

0	0	0	42	24	15	2	2	17	36	0	0	139

Average Monthly Usage (April through October) = 20
Average Monthly Usage (November through March) = 0

Monthly Wood Usage in Tons (0 tons/year - weight based on assumption of 50% **Pinon** and 50% Juniper)

0	0	0	0	0	0	0	0	0	0	0	0	0

Average Monthly Usage (April **through October) =** 0.0
Average Monthly Usage (November through March) = 0.0

Lava Point Residence (Seasonal)

Monthly Propane Usage in Gallons (based on 13.2 gallons April through October)

0	0	0	3.9	2.3	1.4	0.2	0.2	1.6	3.4	0	0	13

Average Monthly Usage (April through October) = 1.9
Average Monthly Usage (November through March) = 0.0

Monthly Wood Usage in Tons (0 tons/year - weight based on assumption of 50% **Pinon** and 50% Juniper)

0	0	0	0	0	0	0	0	0	0	0	0	0

Average Monthly Usage (April **through October) =** 0.0
Average Monthly Usage (November through March) = 0.0

Kolob Canyon Residential Area (Seasonal)

Monthly Propane Usage in Gallons (based on 140 gallons April through October)

0	0	0	42	24	15	2	2	17	36	0	0	139

Average Monthly Usage (April through October) = 19.9
Average Monthly Usage (November through March) = 0.0

Monthly Wood Usage in Tons (0.25 tons/year - weight based on assumption of 50% Pinon and 50% Juniper)

0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2

Average Monthly Usage (April through October) = 0.04
Average Monthly Usage (November through March) = 0.0

Worksheet Three

1999 Vehicle Counts (red indicates calculated values)

Vehicle	Jan	Feb	Mar	Apr	May	June	July	August	Sept	Oct	Nov	Dec	Total	%	Visitors	Total Miles	Annual Avg Mi/Veh
South	4360	4360	33855	53374	57763	75520	73113	79139	68691	59240	36714	22778	568907	0.62349	1434897	3593800	6.3
East	6875	6875	7554	19344	21681	16885	34820	39040	35345	27094	11787	6270	233570	0.25598	591703	3552600	15.2
Canyon	2763	2763	4864	6629	7400	9251	8504	8917	8560	7768	3986	2422	73827	0.08091	184568	701357	9.5
Terrace	997	998	1250	1300	2800	5400	5400	7300	4100	2500	2800	1300	36145	0.03961	84326	234943	6.5
subtotal	14995	14996	47523	80647	89644	107056	121837	134396	116696	96602	55287	32770	912449	1	1809903	8082699	8.9
Tour Bus																	
South	68	64	104	192	323	412	392	488	427	377	174	90	3111			45409	14.6
East	37	34	78	215	480	626	445	572	692	573	109	34	3895			52808	13.6
Canyon	0	0	8	1	4	3	1	13	19	19	6	2	76			809	10.64
subtotal	105	98	190	408	807	1041	838	1073	1138	969	289	126	7082			99026	14.0
													7082				
	1960728	1633072	3593800														
	2777189	775412	3552600														
	541776	159581	701357														
	187200	47743	234943														

Average Monthly Mileage for Vehicles South Entrance April thru October = 280104

Average Monthly Mileage for Vehicles South Entrance November thru March = 326614

Average Monthly Mileage for Vehicles East Entrance April thru October = 396741

Average Monthly Mileage for Vehicles East Entrance November thru March = 155082

Average Monthly Mileage for Vehicles Canyon Entrance April thru October = 77397

Average Monthly Mileage for Vehicles Canyon Entrance November thru March = 31916

Average Monthly Mileage for Vehicles Terrace Entrance April thru October = 26743

Average Monthly Mileage for Vehicles Terrace Entrance Nov thru Mar = 9549

Average Monthly Mileage for Lava Point (Unpaved) Road April through October = 3065

Average Monthly Mileage for Lava Point (Unpaved) Road November through March = 914

Average Monthly Mileage for Kolob VC (Unpaved) Road April through October = 57

Average Monthly Mileage for Kolob VC (Unpaved) Road November through March = 0

ume tour buses will travel through the park when entering from the South or East and 25% will also travel to the lodge and back April thru 12.65

me tour buses will travel through the park when entering from the South or East and 100% will also travel in and out Zion Canyon Nov thru 24.76

Average Monthly Mileage April Through October for Tour Buses = 79246 11321

Average Monthly Mileage November through March for Tour Buses = 19780 3956

RV's	161	150	705	2196	3723	3419	2748	2958	2721	3688	702	368	23539

Assume .5 RV's will act like tour buses and .5 will act like pass. Vehicles (except that RV's will not travel Zion Canyon during shuttle service.)

RV Avg Monthly Mileage April through October = 225688 32241

RV Avg Monthly Mileage November through March = 43755 8751

Worksheet Four
OffRoad Emission Factor Estimate

Revised 30-Dec

Equipment	Fuel	Fuel Density g/gal	BSFC g/kwhr	HC g/kwhr	CO g/kwhr	NOx g/kwhr	PM g/kwhr	HC g/gal	CO g/gal	NOx g/gal	PM g/gal
All Terrain Vehicles, snowmobiles etc	Gasoline	15.122	665	206	523	0.63	3.22	4.68	11.89	0.01	0.07
Compressor (new engine Phase 1)	Gasoline	15.122	720	295	805	1.05	7.7	6.20	16.91	0.02	0.16

Reference: Exhaust Emission Factors for Nonroad Engine Modeling --Spark Ignition

Note: All other emission factors obtained directly from the NEVES study, in g/gal

"Nonroad Engine and Vehicle Emission Study Report" (Publication no. EPA-21A-2001 or EPA460/3-91-002)

http://www.epa.gov/otaq/nonrdmdl.htm#neves

Worksheet Five

LPG Heavy Duty Emissions Calculation [1]

Revised 5-Jan

Light Yellow Background indicates assumed input numbers

Cummins B5.9-159LPG Engine Emissions [2]

Pollutant	Emissions g/bhp-hr	DF(units)?	Emissions (g/mi)
VOC	0.8	1	3.44
CO	0.07	13.935	0.30
NOx	2.29	1.007	**9.85**
PM	0.013	1	0.06

Emissions from Park-Operated LPG Shuttle Buses

Summer Zion	Emissions, Tons/day
VOC	0.007
CO	0.001
NOx	0.020
PM	0.0001

Parameter	Value	Units	Source
density	6.2	lb/gal	Prop of Fuels, alt. Fuels binder
BSEC	6500	Btu/bhp-hr	Emfac7g Emissions Model
MPG	3.35	mi/gal	Zion Shuttle Bus Maintenance Log
LHV	15100	Btu/lb	Prop of Fuels, alt. Fuels binder
CF	4.3	bhp-hr/mi	
Travel	1827	VMT/day	Parks Data Excel Worksheet
Passenger	2994	p/day	Parks Data Excel Worksheet

1:Shuttle Bus only operates in Summer in Zion National Park

2:EF's from Chuck Richardons, Cummins, " Test Information Form"

3:Although emission factors are shown for RV's, the aggregate emission factor documented for private vehicles used included VMT and emissions from RVs and so is only given here for documentation. However, Tour bus emissions were added in separately.

Recreational Vehicle Emissions/Tour Bus Emissions [3]

Gasoline	Baseline		Zion	
g/mi	Summer	Winter	Summer	Winter
VOC	11.079	4.645	4.593	2.545
CO	72.709	64.964	43.433	33.718
NOx	3.256	3.828	2.44	2.908
PM	0.103	0.103	0.103	0.103
VMT				

Diesel	Baseline		Zion	
g/mi	Summer	Winter	Summer	Winter
VOC	5.088	5.088	5.399	5.399
CO	19.067	19.067	20.903	20.903
NOx	11.579	11.579	9.305	9.305
PM	0.646	0.646	0.646	0.646
VMT	377	132	377	132

Emissions from Diesel RVs/Tour Buses

	Baseline		Zion	
g/mi	Summer	Winter	Summer	Winter
VOC	0.0021	0.0007	0.0022	0.0008
CO	0.0079	0.0028	0.0087	0.0030
NOx	0.0048	0.0017	0.0039	0.0014
PM	0.0003	0.0001	0.0003	0.0001

Worksheet Six

Emission Comparison for Zion and National Parks to the Baseline

Revised 5-Jan 1(all emissions for the park specific are using mobile's speeds corrections(MSCF))

Summary	Baseline, FTP, **19.6**		Zion, 16.7		Arches, 22.8	
	S	W	S	W	S	W
VOC	4.5	2.3	3.3	1.37	2.7	1.1
CO	25.4	22.5	**16.9**	**15.5**	13.1	12.0
NOx	2.2	2.4	1.0	1.2	1.0	1.2
PM	0.025	0.025	0.025	0.025	0.025	0.025

***Emission* Factors *for various vehicle Types* (g/mi)**

	Private Vehicles		Gov Vehicle		Shuttle Bus		Tour Buses		Gasoline RV		Diesel RV	
ZION	S	W	S	W	S	W	S	W	S	W	S	W
VOC	3.26	1.37	3.09	1.70	3.44		5.40	5.40	4.59	2.55	5.40	5.40
CO	16.90	15.46	16.24	14.75	0.30		20.90	20.90	43.43	33.72	20.90	20.90
NOx	1.02	1.16	1.56	2.00	**9.85**		9.31	9.31	2.44	2.91	9.31	9.31
PM	0.025	0.025	0.083	0.054	0.056		0.65	0.65	0.10	0.10	0.65	0.65

Government Vehicles in Zion

Gov Veh Zion	VMT/veh/day Gas	Diesel
# vehicles	85	5
summer	28.8	84.8
winter	17	83

Government Vehicles in Zion National Park

No veh[1]	5	85[1]	
	Fuel Use		
Month	Diesel	Gas[3]	No Days
Aug	790	4330	31
Sept	**686**	3560	30
Oct	**826**	3245	31
Nov	823	2095	30
Dec	1316	2009	31
Jan	505	2183	31
Feb	574	2132	29
Mar	855	2373	31
Apr	725	2874	30
May	803	3581	31
Jun	1111	3645	30
July	915	**3978**	31
summer[4]	**5856**	24933	214
winter[5]	4073	10592	152
total	**9929**	36005	**366**
fuel econom	15.5	21	
miles/sumd	**84.8**	**28.8**	
miles/winda	83.1	17.2	

Emissions from On-Road Government Vehicles in Zion National Park

g/day	Summer		Winter	
	Baseline	Zion	Baseline	Zion
VOC	11523	**8875**	4187	**3188**
CO	64245	**46619**	36247	27702
NOx	6241	4474	5173	3765
PM	237	237	101	101

Tons/day	Summer		Winter	
	Baseline	Zion	Baseline	Zion
VOC	0.0127	0.0098	0.0046	0.0035
CO	0.0708	0.0514	0.0400	0.0305
NOx	0.0069	0.0049	0.0057	0.0042
PM	0.0003	0.0003	0.0001	0.0001

1 Air Quality/Emissions Survey
2 Emfac7g, 2000 default run diesel:(.5hd .5ldt) gas:(.5ldv, .5ldt)
3 40 gallons fuel per month was subtracted for other uses
4 Summer is defined as April - October
5 Winter is defined as November - March

Private Vehicles

Emissions from Privately Owned Vehicles in Zion National Park

	Summer		Winter	
g/day	Baseline	Zion	Baseline	Zion
VOC	126611	91305	44446	26816
CO	710641	473098	440724	302090
NOx	60702	28447	47280	22692
PM	700	700	489	489

	Summer		Winter	
Tons/day	Baseline	Zion	Baseline	Zion
VOC	0.140	0.101	0.049	0.030
CO	0.783	0.522	0.486	0.333
NOx	0.067	0.031	0.052	0.025
PM	0.001	0.0008	0.001	0.0005

Decreased Private Vehicle Useage Due to Buses

Emissions if bus goers rode their own (Emissions offset)	
ton/sday	Zion
VOC	0.039
CO	0.203
NOx	0.012
PM	0.0003

Emissions from bus goers riding (Emissions Addition)	
ton/sday	Zion
VOC	0.007
CO	0.001
NOx	0.020
PM	0.000

VMT/day	
Summer	Winter
27999	19545

Emissions Change from Shuttle bus Implementation

Tons/day	Zion	% of Total
VOC	-0.032	-27%
CO	-0.202	-35%
NOx	0.008	13%
PM	0.000	-13%

All On-Road Emissions

Daily On-Road Emissions for Zion

	Summer		Winter	
Tons/day	Baseline	Zion	Baseline	Zion
VOC	0.161	0.120	0.054	0.034
CO	0.863	0.582	0.529	0.367
NOx	0.098	0.060	0.060	0.031
PM	0.001	0.001	0.001	0.001

Worksheet Six, Page 2

Emission Comparison for Zion and National Parks to the Baseline

Summarized Emission* Factors *for* *Baseline and Park Specific (g/mi)

PS/BaseS VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	4.083	4.262	5.374	4.607	11.079	0.718	1.107	5.088	6.74	4.522
Arches	2.511	2.52	2.356	2.449	3.521	0.425	0.712	4.292	6.962	2.651
Zion	3.156	*3.007*	2.832	2.931	4.593	0.535	0.896	5.399	7.42	3.261

PS CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	21.907	26.736	35.463	29.447	72.709	1.867	3.274	19.067	30.927	25.381
Arches	11.712	14.701	14.696	14.699	31.139	0	2.294	15.216	28.949	13.107
Zion	15.235	18.703	18.738	18.718	43.433	0	3.151	20.903	34.245	16.897

PS NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.32	1.515	2.034	1.676	3.256	1.367	1.498	11.579	0.537	2.168
Arches	0.821	0.993	1.126	1.051	2.575	0	1.166	8.238	0.592	1.004
Zion	0.814	1.002	1.14	1.062	2.44	0	1.317	9.305	0.495	1.016

PS PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

PW VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.717	2.247	3.174	2.535	4.645	0.718	1.107	5.088	3.914	2.274
Arches	0.887	1.17	1.136	1.155	1.757	0.425	0.712	4.292	3.946	1.099
Zion	1.12	1.45	1.415	1.435	2.545	0.535	0.896	5.399	4.531	1.372

PW CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	18.767	24.431	32.271	26.866	64.964	1.867	3.274	19.067	39.669	22.549
Arches	10.212	13.943	13.657	13.819	24.174	0	2.294	15.216	37.186	12.015
Zion	13.288	17.746	17.42	17.604	33.718	0	3.151	20.903	43.99	15.456

PW NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.551	1.807	2.431	2.001	3.828	1.367	1.498	11.579	0.655	2.419
Arches	0.952	1.176	1.324	1.24	3.068	0	1.166	8.238	0.722	1.15
Zion	0.945	1.186	1.341	1.254	2.908	0	1.317	9.305	0.604	1.161

PW

PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

BaseS

VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	4.083	4.262	5.374	4.607	11.079	0.718	1.107	5.088	6.74	4.522
Arches	3.759	3.946	4.943	4.256	10.196	0.639	0.986	4.529	6.549	4.158
Zion	4.71	4.712	5.956	5.099	12.382	0.804	1.24	5.697	6.972	5.127

BaseS

CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	21.907	26.736	35.463	29.447	72.709	1.867	3.274	19.067	30.927	25.381
Arches	18.604	23.223	31.186	25.697	61.689	1.594	2.795	16.278	28.382	21.763
Zion	24.002	29.415	39.064	32.412	86.045	2.189	3.84	22.362	33.575	28.147

BaseS

NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.32	1.515	2.034	1.676	3.256	1.367	1.498	11.579	0.537	2.168
Arches	1.346	1.53	2.059	1.694	3.348	1.29	1.414	10.934	0.592	2.149
Zion	1.337	1.532	2.053	1.694	3.173	1.458	1.597	12.35	0.495	2.233

BaseS

PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

BaseW

VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.717	2.247	3.174	2.535	4.645	0.718	1.107	5.088	3.914	2.274
Arches	1.508	2.006	2.853	2.269	3.927	0.639	0.986	4.529	3.669	2.01
Zion	1.898	2.478	3.493	2.793	5.514	0.804	1.24	5.697	4.21	2.527

BaseW

CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	18.767	24.431	32.271	26.866	64.964	1.867	3.274	19.067	39.669	22.549
Arches	15.939	21.231	28.468	23.479	55.118	1.594	2.795	16.278	36.404	19.355
Zion	20.576	26.901	35.557	29.59	76.88	2.189	3.84	22.362	43.065	25.032

BaseW

NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All
FTP	1.551	1.807	2.431	2.001	3.828	1.367	1.498	11.579	0.655	2.419
Arches	1.581	1.824	2.462	2.022	3.937	1.29	1.414	10.934	0.722	2.403
Zion	1.571	1.827	2.455	2.022	3.73	1.458	1.597	12.35	0.604	2.486

BaseW

PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

Worksheet Seven

Effect of Driving Pattern on Mobile Emissions in the National Parks

Revised 5-Jan

all emsisions on this page calculated using Park specific fleet data
Light Yellow Background indicates assumed input numbers

Average Speed Effects on Emissions (Using CMEM)*

Emission	FTP, 19.6		Zion, 16.7		Arches, 22.8	
(g/mi)	S	W	S	W	S	W
VOC	**2.86**	**1.25**	**2.89**	1.24	2.19	0.97
CO	15.50	14.18	26.12	23.50	11.19	10.33
NOx	1.00	1.14	0.75	0.85	0.65	0.73

Change in Emissions from FTP cycle (19.6)

	Zion, 16.7		Arches, 22.8	
	S	W	S	W
VOC	1%	0%	-24%	-22%
CO	**69%**	**66%**	-28%	-27%
NOx	-25%	-25%	-35%	-36%

*effects only seen for light duty

Average Speed Effects on Emissions (Using Mobile5b)

Emission	FTP, 19.6		Zion, 16.7		Arches, 22.8	
g/mi	S	W	S	W	S	W
VOC	2.9	1.2	3.3	1.37	2.7	1.1
CO	15.5	14.2	**16.9**	15.5	13.1	12.0
NOx	1.0	1.1	1.0	1.2	1.0	1.2
PM	0.025	0.025	0.025	0.025	0.025	0.025

	Zion, 16.7		Arches, 22.8	
	S	W	S	W
VOC	14%	10%	-7%	-12%
CO	9%	9%	-15%	-15%
NOx	2%	2%	1%	1%

VMTmix

MOBILE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL
Base	0.616	0.191	0.086	0	0.031	0.002	0.001	0.068	0.006	1.001
Parks	0.701	0.138	0.106	0.00000	0.008	0.00000	0.003	0.016	0.028	1.000

PART5	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES
Base	0.615	0.191	0.086	0.031	0.006	0.0019	0.001	0.0146	0	0.0146	0.034	0.0049
Parks	0.7007	0.1372	0.1064	0.0079	0.0278	0.0004	0.0033	0.0035	0	0.0035	0.0081	0.0012

CMEM Driving Correction (from FTP)

		LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC
	Arches	0.75	0.695	0.695	0	1	1	1	1	1
VOC	Zion	1.083	0.797	0.797	0	1	1	1	1	1
	Arches	**0.696**	0.685	0.685	0	1	1	1	1	1
CO	Zion	2	1.191	1.191	0	1	1	1	1	1
	Arches	0.571	0.571	0.571	0	1	1	1	1	1
NOx	Zion	0.714	0.667	0.667	0	1	1	1	1	1

Worksheet Seven Page 2
Effect of Driving Pattern on Mobile Emissions in the National Parks

Summarized Emission Factors Specific to Parks (g/mi)

PS VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	2.715	2.715	2.549	2.643	3.901	0.477	0.8	4.822	7.169	2.86			
Arches	2.511	2.52	2.356	2.449	3.521	0.425	0.712	4.292	6.962	2.651			
Zion	3.156	3.007	2.832	2.931	4.593	0.535	0.896	5.399	7.42	3.261			
PS CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	14.004	17.197	17.358	17.267	36.702	0	2.686	17.823	31.545	15.5			
Arches	11.712	14.701	14.696	14.699	31.139	0	2.294	15.216	28.949	13.107			
Zion	15.235	18.703	18.738	18.718	43.433	0	3.151	20.903	34.245	16.897			
PS **NOx**	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	0.804	0.99	1.126	1.049	2.504	0	1.235	8.724	0.537	0.998			
Arches	0.821	0.993	1.126	1.051	2.575	0	1.166	8.238	0.592	1.004			
Zion	0.814	1.002	1.14	1.062	2.44	0	1.317	9.305	0.495	1.016			
PS PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
PW VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	1.017	1.319	1.29	1.306	2.111	0.477	0.8	4.822	4.21	1.246			
Arches	0.887	1.17	1.136	1.155	1.757	0.425	0.712	4.292	3.946	1.099			
Zion	1.12	1.45	1.415	1.435	2.545	0.535	0.896	5.399	4.531	1.372			
PW CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	12.213	16.318	16.139	16.24	28.492	0	2.686	17.823	40.522	14.18			
Arches	10.212	13.943	13.657	13.819	24.174	0	2.294	15.216	37.186	12.015			
Zion	13.288	17.746	17.42	17.604	33.718	0	3.151	20.903	43.99	15.456			
PW **NOx**	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	0.932	1.171	1.324	1.238	2.984	0	1.235	8.724	0.655	1.141			
Arches	0.952	1.176	1.324	1.24	3.068	0	1.166	8.238	0.722	1.15			
Zion	0.945	1.186	1.341	1.254	2.908	0	1.317	9.305	0.604	1.161			
PW PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

Worksheet Seven Page 3

Effect of Driving Pattern on Mobile Emissions in the National Parks

Summarized Emission Factors- Baseline(g/mi)

BaseS													
VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	4.083	4.262	5.374	4.607	11.079	0.718	1.107	5.088	6.74	4.522			
Arches	3.759	3.946	4.943	4.256	10.196	0.639	0.986	4.529	6.549	4.158			
Zion	4.71	4.712	5.956	5.099	12.382	0.804	1.24	5.697	6.972	5.127			
BaseS													
CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	21.907	26.736	35.463	29.447	72.709	1.867	3.274	19.067	30.927	25.381			
Arches	18.604	23.223	31.186	25.697	61.689	1.594	2.795	16.278	28.382	21.763			
Zion	24.002	29.415	39.064	32.412	86.045	2.189	3.84	22.362	33.575	28.147			
BaseS													
NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	1.32	1.515	2.034	1.676	3.256	1.367	1.498	11.579	0.537	2.168			
Arches	1.346	1.53	2.059	1.694	3.348	1.29	1.414	10.934	0.592	2.149			
Zion	1.337	1.532	2.053	1.694	3.173	1.458	1.597	12.35	0.495	2.233			
BaseS													
PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
BaseW													
VOC	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	1.717	2.247	3.174	2.535	4.645	0.718	1.107	5.088	3.914	2.274			
Arches	1.508	2.006	2.853	2.269	3.927	0.639	0.986	4.529	3.669	2.01			
Zion	**1.898**	2.478	3.493	2.793	5.514	0.804	1.24	5.697	4.21	2.527			
BaseW													
CO	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	18.767	24.431	32.271	26.866	64.964	1.867	3.274	19.067	39.669	22.549			
Arches	15.939	21.231	28.468	23.479	55.118	1.594	2.795	16.278	36.404	19.355			
Zion	20.576	26.901	35.557	29.59	76.88	2.189	3.84	22.362	43.065	25.032			
BaseW													
NOx	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All			
FTP	1.551	1.807	2.431	2.001	3.828	1.367	1.498	11.579	0.655	2.419			
Arches	1.581	1.824	2.462	2.022	3.937	1.29	1.414	10.934	0.722	2.403			
Zion	1.571	1.827	2.455	2.022	3.73	1.458	1.597	12.35	0.604	2.486			
BaseW													
PM	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
FTP	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Arches	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025
Zion	0.013	0.016	0.022	0.103	0.02	0.19	0.213	0.172	0	0.646	0.739	0.617	0.025

Worksheet Eight
Vehicle Emissions Comparison for Utah National Parks Fleet Distribution

Revised 30-Dec

Summer, 20 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	4.03	2.68	21.39	13.64	1.33	0.81	0.013	0.013
LDGT1	4.22	2.69	26.28	16.84	1.51	0.99	0.016	0.016
LDGT2	5.32	2.52	34.96	16.96	2.03	1.12	0.022	0.022
HDGV	10.96	3.85	71.14	35.91	3.27	2.51	0.103	0.103
LDDV	0.71	0.47	1.83	0.00	1.36	0.00	0.190	0.190
LDDT	1.09	0.79	3.21	2.63	1.49	1.23	0.213	0.213
HDDV	5.01	4.75	18.67	17.46	11.49	8.66	0.016	0.016
MC	6.71	7.14	30.60	31.21	0.54	0.54	0.020	0.020
All	4.47	2.83	24.86	15.13	2.17	1.00	0.032	0.025

Summer, 57 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	2.50	1.69	9.97	5.38	1.85	1.11	0.013	0.013
LDGT1	2.87	1.85	14.76	8.08	2.16	1.37	0.016	0.016
LDGT2	3.48	1.69	21.75	7.29	2.94	1.53	0.022	0.022
HDGV	7.14	2.17	43.49	21.95	4.33	3.33	0.103	0.103
LDDV	0.32	0.22	0.94	0.00	1.74	0.00	0.190	0.190
LDDT	0.50	0.36	1.65	1.36	1.90	1.57	0.213	0.213
HDDV	2.29	2.17	9.62	8.99	14.70	11.08	0.016	0.016
MC	6.05	6.42	25.35	25.86	1.03	1.03	0.020	0.020
All	2.80	1.85	12.99	6.71	2.95	1.36	0.032	0.025

Winter, 20 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	1.68	1.00	18.33	11.90	1.56	0.94	0.013	0.013
LDGT1	2.21	1.30	24.02	15.98	1.80	1.17	0.016	0.016
LDGT2	3.13	1.26	31.82	15.77	2.43	1.32	0.022	0.022
HDGV	4.54	2.06	63.57	27.88	3.84	3.00	0.103	0.103
LDDV	0.71	0.47	1.83	0.00	1.36	0.00	0.190	0.190
LDDT	1.09	0.79	3.21	2.63	1.49	1.23	0.213	0.213
HDDV	5.01	4.75	18.67	17.46	11.49	8.66	0.016	0.016
MC	3.88	4.17	39.25	40.09	0.66	0.66	0.020	0.020
All	2.24	1.22	22.09	13.85	2.42	1.14	0.032	0.025

Winter, 57 mph

	VOC		CO		Nox		PM	
	Base	Parks	Base	Parks	Base	Parks	Base	Parks
LDGV	0.90	0.50	8.58	4.69	2.18	1.28	0.013	0.013
LDGT1	1.30	0.73	13.59	7.63	2.58	1.62	0.016	0.016
LDGT2	1.93	0.69	20.40	6.75	3.52	1.80	0.022	0.022
HDGV	1.77	0.69	38.86	17.04	5.09	3.97	0.103	0.103
LDDV	0.32	0.22	0.94	0.00	1.74	0.00	0.190	0.190
LDDT	0.50	0.36	1.65	1.36	1.90	1.57	0.213	0.213
HDDV	2.29	2.17	9.62	8.99	14.70	11.08	0.016	0.016
MC	3.03	3.26	32.52	33.21	1.25	1.25	0.020	0.020

Worksheet Eight, Page 2
Vehicle Emissions Comparison for Utah National Parks Fleet Distribution

Summer, 20 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-33%	-36%	-39%	0%
LDGT1	-28%	-36%	-36%	-35%	0%
LDGT2	24%	-53%	-51%	-45%	0%
HDGV	-75%	-65%	-50%	-23%	0%
LDDV	-79%	-34%	-100%	-100%	0%
LDDT	233%	-28%	-18%	-18%	0%
HDDV	-76%	-5%	-7%	-25%	0%
MC	364%	6%	2%	0%	0%
All	0%	-37%	-39%	-54%	-22%

Summer, 57 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-33%	-46%	-40%	0%
LDGT1	-28%	-36%	-45%	-37%	0%
LDGT2	24%	-51%	-67%	-48%	0%
HDGV	-75%	-70%	-50%	-23%	0%
LDDV	-79%	-34%	-100%	-100%	0%
LDDT	233%	-28%	-18%	-18%	0%
HDDV	-76%	-5%	-7%	-25%	0%
MC	364%	6%	2%	0%	0%
All	0%	-34%	-48%	-54%	-22%

Winter, 20 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-41%	-35%	-40%	0%
LDGT1	-28%	-41%	-33%	-35%	0%
LDGT2	24%	-60%	-50%	-46%	0%
HDGV	-75%	-55%	-56%	-22%	0%
LDDV	-79%	-34%	-100%	-100%	0%
LDDT	233%	-28%	-18%	-18%	0%
HDDV	-76%	-5%	-7%	-25%	0%
MC	364%	8%	2%	0%	0%
All	0%	-45%	-37%	-53%	-22%

Winter, 57 mph

	VMTmix	VOC	CO	Nox	PM
LDGV	14%	-44%	-45%	-41%	0%
LDGT1	-28%	-44%	-44%	-37%	0%
LDGT2	24%	-64%	-67%	-49%	0%
HDGV	-75%	-61%	-56%	-22%	0%
LDDV	-79%	-34%	-100%	-100%	0%
LDDT	233%	-28%	-18%	-18%	0%
HDDV	-76%	-5%	-7%	-25%	0%
MC	364%	7%	2%	0%	0%
All	0%	-45%	-46%	-53%	-22%

Percent Change in Emissions from Baseline using National Parks Fleet Distribution Data

	20 mph		57 mph	
	Summer	Winter	Summer	Winter
VOC	-37%	-45%	-34%	-45%
CO	-39%	-37%	-48%	-46%
Nox	-54%	-53%	-54%	-53%
PM	-22%	-22%	-22%	-22%

	VMTmix	
Class	Base	Parks
LDGV	0.616	0.701
LDGT1	0.191	0.137
LDGT2	0.086	0.106
HDGV	0.031	0.008
LDDV	0.002	0.000
LDDT	0.001	0.003
HDDV	0.068	0.016
MC	0.006	0.028
All	1.00	1.00

Base/ Baseline	This is emissions estimated using national fleet distribution data (VMT mix, user reg), FTP driving cycle
P/Parks	This is emissions data using Park specific fleet distribution data & Temperatures

Appendix C

Inputs for Mobile Source Emission Modeling

Part5 Input File: PW2.in

```
2000 Utah PM10 1.3.01 (for fug dust, winter)
2     :VMFLAG (alternate VMT mixes)
1     :MYMRFG (alternate mileage accumulation rates & registration)
2     :IMFLAG (Inspection and maintenance)
1     :RFGFLG (2 to apply reformulated gasoline effects, 1 not to)
3     :OUTFMT (indicates type of output format)
2     :IDLFLG (2 to print, 1 not to print idle emission factors)
2     :SO2FLG (2 to print Gaseous SO2 emissions, 1 not to print them)
1     :PRTFLG (determines which pollutants to print out)
1     :BUSFLG (determines which alternative bus cycles to print out)
2 2000  1 20.0         : region, year, speed cycle, speed
08.9 0.29  2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
74
UT Local                        :scene name
10.   -- Particle size cutoff
4600
04
0.6600 0.2080 0.0840 0.0120 0.0050 0.0020
0.0010 0.0060 0.0000 0.0060 0.0140 0.0020
2 2000  1 20.0         : region, year, speed cycle, speed
08.9   0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
74
Base                            :scene name
10.   -- Particle size cutoff
4600
04
0.6150 0.1910 0.0860 0.0310 0.0060 0.0019
0.0010 0.0146 0.0000 0.0146 0.0340 0.0049
2 2000 1 20.0     : region, year, speed cycle, speed
08.9   0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
74
Parks                   :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 19.6 : region, year, speed cycle, speed
08.9 0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
74
Parks FTP               :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 22.8 : region, year, speed cycle, speed
08.9 0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
74
Parks Arches                    :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 16.7 : region, year, speed cycle, speed
08.9 0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
74
Parks Zion                      :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
```

Part5 Input File: PS2.in

```
2000 Utah PM10 1.3.01 (fugitive emissions estimate, Summer)
2     :VMFLAG (alternate VMT mixes)
1     :MYMRFG (alternate mileage accumulation rates & registration)
2     :IMFLAG (Inspection and maintenance)
1     :RFGFLG (2 to apply reformulated gasoline effects, 1 not to)
3     :OUTFMT (indicates type of output format)
2     :IDLFLG (2 to print, 1 not to print idle emission factors)
2     :SO2FLG (2 to print Gaseous SO2 emissions, 1 not to print them)
1     :PRTFLG (determines which pollutants to print out)
1     :BUSFLG (determines which alternative bus cycles to print out)
2 2000  1 20.0        : region, year, speed cycle, speed
08.9 0.29  2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
55
UT Local                        :scene name
10.   -- Particle size cutoff
4600
04
0.6600 0.2080 0.0840 0.0120 0.0050 0.0020
0.0010 0.0060 0.0000 0.0060 0.0140 0.0020
2 2000  1 20.0         : region, year, speed cycle, speed
05.7   0.29 2         : unpaved silt%, ind. silt g/m^2, WHEELFLG
55
Base                            :scene name
10.   -- Particle size cutoff
4600
04
0.6150 0.1910 0.0860 0.0310 0.0060 0.0019
0.0010 0.0146 0.0000 0.0146 0.0340 0.0049
2 2000 1 20.0    : region, year, speed cycle, speed
08.9   0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
55
Parks                   :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 19.6 : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
55
Parks FTP               :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 22.8 : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
55
Parks Arches                    :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
2 2000 1 16.7 : region, year, speed cycle, speed
08.9 0.29 2        : unpaved silt%, ind. silt g/m^2, WHEELFLG
55
Parks Zion                      :scene name
10.   -- Particle size cutoff
4600
04
0.7007 0.1372 0.1064 0.0079 0.0278 0.0004
0.0033 0.0035 0.0000 0.0035 0.0081 0.0012
```

MOBILE5b Input file: BaseS.in

```
1           PROMPT
  Utah basic I/M program for summer 2000, based on Utah and Weber
Counties 11.13.00
1           TAMFLG
1           SPDFLG
1           VMFLAG    could change
1           MYMRFG    def reg distrib, def annual mileage accum
1           NEWFLG    def exhaust emission rates
6           IMFLAG    Basic I/M program TTC
1           ALHFLG    no extra load corrections, ac, towing
1           ATPFLG    no anti-tampering program, could change
5           RLFLAG    no refueling losses calculated
2           LOCFLG    one LAP for all scenarios
2           TEMFLG    use only ambient temp
6           OUTFMT    spreadsheet
4           PRTFLG    Print exhaust HC, CO and NOx results.
2           IDLFLG    idle calculated
3           NMHFLG    Calculate emissions for volatile organic
hydrocarbons.
2           HCFLAG    Separate VOC and sum
1 1 2 1
86 14 68 50 01  01 096 111 2222 1111                I/M Basic Program
Utah BasicS       E  65.  100.  12.1  12.1 92 2  1 1     Local Area Parameter
.700  .300  .027  .027 1                            Oxy Fuels
2 00  57.0  80.0  20.6  27.3  20.6  01                      Am
2 00  41.5  80.0  20.6  27.3  20.6  01                      mid
2 00  32.7  80.0  20.6  27.3  20.6  01                      pm
2 00  25.4  80.0  20.6  27.3  20.6  01                      ff
2 00  20.0  80.0  20.6  27.3  20.6  01                      Local
2 00  19.6  80.0  20.6  27.3  20.6  01                      FTP
2 00  22.8  80.0  20.6  27.3  20.6  01                      Arches
2 00  16.7  80.0  20.6  27.3  20.6  01                      Zion
000000000000000000000000000000000000000000000000000000000000000000000000000
00000000
```

MOBILE5b Input file: BaseW.in

```
1           PROMPT
  Utah basic I/M program for winter 2000, based on Utah and Weber
Counties 1.02.01
1           TAMFLG
1           SPDFLG
1           VMFLAG    could change
1           MYMRFG    def reg distrib, def annual mileage accum
1           NEWFLG    def exhaust emission rates
6           IMFLAG    Basic I/M program TTC
1           ALHFLG    no extra load corrections, ac, towing
1           ATPFLG    no anti-tampering program, could change
5           RLFLAG    no refueling losses calculated
2           LOCFLG    one LAP for all scenarios
2           TEMFLG    use only ambient temp
6           OUTFMT    spreadsheet
4           PRTFLG    Print exhaust HC, CO and NOx results.
2           IDLFLG    idle calculated
3           NMHFLG    Calculate emissions for volatile organic
hydrocarbons.
2           HCFLAG    Separate VOC and sum
1 1 2 1
86 14 68 50 01  01  096 111 2222 1111                I/M Basic Program
Utah BasicW       E  32.   54.  12.1  12.1 92 2  1 1     Local Area Parameter
.700  .300  .027  .027 1                             Oxy Fuels
2 00  57.0  42.0  20.6  27.3  20.6  01                      Am
2 00  41.5  42.0  20.6  27.3  20.6  01                      mid
2 00  32.7  42.0  20.6  27.3  20.6  01                      pm
2 00  25.4  42.0  20.6  27.3  20.6  01                      ff
2 00  20.0  42.0  20.6  27.3  20.6  01                      Local
2 00  19.6  42.0  20.6  27.3  20.6  01                      FTP
2 00  22.8  42.0  20.6  27.3  20.6  01                      Arches
2 00  16.7  42.0  20.6  27.3  20.6  01                      Zion
0000000000000000000000000000000000000000000000000000000000000000000000000
00000000
```

MOBILE5b Input file: PS.in

```
1           PROMPT
  Utah basic I/M program for summer 2000, Parks VMT 11.13.00
1           TAMFLG
1           SPDFLG
3           VMFLAG - one VMT mix for all scenarios
3           MYMRFG - user reg distrib by age, def annual mileage accum
1           NEWFLG - def exhaust emission rates
6           IMFLAG - Basic I/M program TTC
1           ALHFLG - no extra load corrections,  ac, towing
1           ATPFLG - no anti-tampering program, could change
5           RLFLAG - no refueling losses calculated
2           LOCFLG - one LAP for all scenarios
2           TEMFLG - use only ambient temp
6           OUTFMT - spreadsheet
4           PRTFLG - Print exhaust HC,  CO and NOx results.
2           IDLFLG - idle calculated
3           NMHFLG - Calculate emissions for volatile organic HC.
2           HCFLAG - Separate VOC and sum
.701.138.106.008.000.003.016.028                VMT Park specific mix
  .158 .158 .158  .158  .059  .059  .059  .059  .025  .025     registration
dist. by age
  .025 .010 .010  .010  .004  .004  .004  .004  .004  .002     LDGV
  .002 .002 .000  .000  .000
  .161 .161 .161  .161  .043  .043  .043  .043  .025  .025     LDGT1
  .025 .018 .018  .018  .010  .010  .010  .010  .004  .004
  .004 .001 .001  .001  .000
  .000 .228 .228  .228  .049  .049  .049  .049  .026  .026     LDGT2
  .026 .011 .011  .011  .002  .002  .002  .002  .000  .000
  .000 .000 .000  .000  .000
  .183 .183 .183  .183  .050  .050  .050  .050  .022  .022     HDGV
  .022 .000 .000  .000  .000  .000  .000  .000  .000  .000
  .000 .000 .000  .000  .000
  .158 .158 .158  .158  .059  .059  .059  .059  .025  .025     LDDV
  .025 .010 .010  .010  .004  .004  .004  .004  .004  .002
  .002 .002 .000  .000  .000
  .161 .161 .161  .161  .043  .043  .043  .043  .025  .025     LDDT
  .025 .018 .018  .018  .010  .010  .010  .010  .004  .004
  .004 .001 .001  .001  .000
  .147 .147 .147  .147  .088  .088  .088  .088  .020  .020     HDDV
  .020 .000 .000  .000  .000  .000  .000  .000  .000  .000
  .000 .000 .000  .000  .000
  .100 .100 .100  .100  .100  .100  .100  .100  .050  .050     MC
  .050 .050 .000  .000  .000  .000  .000  .000  .000  .000
  .000 .000 .000  .000  .000
1 1 2 1
86 14 68 50 01 01  096 111 2222 1111              I/M Basic Program
Ut ParksVMT S     E   65.  100.  12.1 12.1  92  2 1  1     Local Area Parameter
.700 .300 .027 .027 1                           Oxy Fuels
2 00 57.0 80.0 20.6 27.3 20.6 01                        Am
2 00 41.5 80.0 20.6 27.3 20.6 01                        mid
2 00 32.7 80.0 20.6 27.3 20.6 01                        pm
2 00 25.4 80.0 20.6 27.3 20.6 01                        ff
2 00 20.0 80.0 20.6 27.3 20.6 01                        Local
2 00 19.6 80.0 20.6 27.3 20.6 01                        FTP
2 00 22.8 80.0 20.6 27.3 20.6 01                        Arches
2 00 16.7 80.0 20.6 27.3 20.6 01                        Zion
```

MOBILE5b Input file: PW.in

```
1           PROMPT
  Utah basic I/M program for winter 2000, Parks VMT 12.29.00
1           TAMFLG
1           SPDFLG
3           VMFLAG - one VMT mix for all scenarios
3           MYMRFG - user reg distrib by age, def annual mileage accum
1           NEWFLG - def exhaust emission rates
6           IMFLAG - Basic I/M program TTC
1           ALHFLG - no extra load corrections,  ac, towing
1           ATPFLG - no anti-tampering program, could change
5           RLFLAG - no refueling losses calculated
2           LOCFLG - one LAP for all scenarios
2           TEMFLG - use only ambient temp
6           OUTFMT - spreadsheet
4           PRTFLG - Print exhaust HC,  CO and NOx results.
2           IDLFLG - idle calculated
3           NMHFLG - Calculate emissions for volatile organic HC.
2           HCFLAG - Separate VOC and sum
.701.138.106.008.000.003.016.028                VMT Park specific mix
 .158 .158 .158 .158 .059 .059 .059 .059 .025 .025    registration
dist. by age
 .025 .010 .010 .010 .004 .004 .004 .004 .004 .002    LDGV
 .002 .002 .000 .000 .000
 .161 .161 .161 .161 .043 .043 .043 .043 .025 .025    LDGT1
 .025 .018 .018 .018 .010 .010 .010 .010 .004 .004
 .004 .001 .001 .001 .000
 .000 .228 .228 .228 .049 .049 .049 .049 .026 .026    LDGT2
 .026 .011 .011 .011 .002 .002 .002 .002 .000 .000
 .000 .000 .000 .000 .000
 .183 .183 .183 .183 .050 .050 .050 .050 .022 .022    HDGV
 .022 .000 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
 .158 .158 .158 .158 .059 .059 .059 .059 .025 .025    LDDV
 .025 .010 .010 .010 .004 .004 .004 .004 .004 .002
 .002 .002 .000 .000 .000
 .161 .161 .161 .161 .043 .043 .043 .043 .025 .025    LDDT
 .025 .018 .018 .018 .010 .010 .010 .010 .004 .004
 .004 .001 .001 .001 .000
 .147 .147 .147 .147 .088 .088 .088 .088 .020 .020    HDDV
 .020 .000 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
 .100 .100 .100 .100 .100 .100 .100 .100 .050 .050    MC
 .050 .050 .000 .000 .000 .000 .000 .000 .000 .000
 .000 .000 .000 .000 .000
1 1 2 1
86 14 68 50 01 01 096 111 2222 1111              I/M Basic Program
Ut ParksVMT W    E   32.  54.   12.1 12.1  92 2 1 1    Local Area Parameter
.700 .300 .027 .027 1                           Oxy Fuels
2 00 57.0 42.0 20.6 27.3 20.6 01                      Am
2 00 41.5 42.0 20.6 27.3 20.6 01                      mid
2 00 32.7 42.0 20.6 27.3 20.6 01                      pm
2 00 25.4 42.0 20.6 27.3 20.6 01                      ff
2 00 20.0 42.0 20.6 27.3 20.6 01                      Local
2 00 19.6 42.0 20.6 27.3 20.6 01                      FTP
2 00 22.8 42.0 20.6 27.3 20.6 01                      Arches
2 00 16.7 42.0 20.6 27.3 20.6 01                      Zion
```

Appendix D

Miscellaneous Documents Provided by Zion Park Personnel

Appendix E

Field Notes – Zion National Park

August 16-19, 2000

August 16th

Through arrangements made the prior day, met with Dave Sharrow at 0800 at the park administrative offices. Dave was an extremely helpful person and definitely should be mentioned in the acknowledgements section of the Zion Park report. We were introduced to Jeff Bradybaugh (435) 772-0208, and Carolyn Sandlin (435) 772-0210. Jeff indicated that many of the park employees were offsite due to the fires in other parks. I informed him that our intent for this visit would be to simply collect data on vehicle activity (vehicle fleet mix, and driving modes) and that we would be back in October or November to do the rest. Jeff indicated that if we returned after the shuttle service is discontinued, we would be able to make better estimates of the pollution reduction benefits of the new shuttle service.

Dave indicated that Dr. Gary Machlis from the University of Idaho had just completed a visitor survey similar to what he had done in 1992. Dave provided us with a copy of the 1992 report and suggested that we contact Dr. Machlis to obtain his latest information. We were also provided with a sheet entitled Summary of Pullouts in Zion National Park, which shows the length in miles of each of the roadways. We were also given some information on lodging/dining in Zion Canyon. Dave provided us with a list of telephone numbers for Zion park personnel. He also gave us three copies of his responses for Zion to the recent survey questionnaire that Don Shepherd had sent out.

Dave intended to introduce us to Dave Karaszewski (435) 772-0279, but he was not in his office. Mr. Karaszewski will be a good information source for historical data and shuttle information. We were introduced to Julie at the dispatch office who informed the park police that we would be driving around the park for the next several days. We met Karen Frauson (435) 772-0176 who works in the fee office and will be a good source for info on the numbers of vehicles entering the park and the dates/times. Other individuals noted to us by Dave include: Judy Rozelle, Concession Coordinator (0145), Eddie Lopez, Asst. Superintendent (0141), Jeff Ballard, Road and Trail Foreman (0198), Jim Starling Building and Utilities Foreman (0200), and Fred Hoeger, District Ranger at Kolob Canyons (435) 586-9578. We were informed that Jeff Ballard and Jim Starling share the responsibilities for park maintenance. Dave took us over to the visitor center where he obtained a set of topo maps covering the park for us. He introduced us to Ray O'Neil at the Visitor Center's Back Country Office (0163). Ray indicated that he, Cindy Purcell, and Cody Cole work at the office and if we will call them in advance of our next visit and let them know what type of information we need from them, they will put it together for us.

We then drove through the South Entrance campgrounds with Dave. It appeared that loops A & B within the Watchman Campground have electricity at each campsite while loops C, D, and E do not. We only observed two campfires during our drive through. However, all campsites have fire rings and it was about midday at the time of our tour. We made a quick pass by the shuttle bus maintenance facility and then drove past the park maintenance area and park personnel housing. Chimneys were observed on most of the park personnel residences and stacks of wood noted outside many of the homes. There is a large propane tank near the residence area, which suggests that propane might be the main fuel source – although that needs to be confirmed. The fueling station for park vehicles does not employ stage II vapor recovery. A road sweeper was noted and Dave said he thought it was only used very sparingly. There is a waste oil burner located at the park maintenance facility. I mentioned to Dave that these burners were fairly high emitters of heavy metals from the waste oil. There are a number of construction type vehicles at various points in the area of the greenhouse and the maintenance yard (road graders, front-loaders, etc.).

Dave indicated that park personnel do tree pruning and they pile the materials and burn it, mainly during the winter season. There is apparently some prescribed burning that goes on in the upper plateaus. For

more information on that burning Dave suggested that we contact Art Litterell (0188) or Henry Bastian (0193).

Dave noted that volcanic cinders are used to cover the oil/asphalt used for road repairs. Asphalt used comes from outside the park.

Dave also indicated that there are 30 power units and 19 trailer units used in the shuttle system.

After lunch, we parted with Dave in order to begin to collect some in-use data. We picked up a white Ford Explorer (Nevada license 633 KNP) at the gate entrance and began to follow it. The vehicle drove into the visitor center parking lot and parked. The GPS record is Zion 816-1 for this driving pattern. We then proceeded to spend the next twenty minutes driving through the visitor center parking lot video taping vehicles parked there. The tape is marked as Zion1816.

At 1:41 pm (Mountain Time), we picked up a vehicle with the intent to follow it to its destination within the park. However, within two minutes, one of the shuttle buses (license I269891) pulled in front of us and we then switched to following the shuttle bus to observe their driving patterns. The bus traveled to the Temple of Sinawava making several stops along the way and during its return to the visitor center. We lost connection with satellites on two occasions during the return trip. However, both of these were very short in duration and are noted on the printout and graphs. The data on this driving pattern is recorded as Zion 0816-2.

At 3:07 pm we picked up a Toyota Camry (California 3TAZ270) and followed it to the point where it exited the park through the East gate at approximately 3:34 pm. We noted that the elevation difference (starting from just about the turnoff for Zion Lodge/Temple of Sinawava and ending at the East Fee Station) was 1645 feet. The distance was 9 miles, yielding an average rate of incline of 182.8 feet per mile.

At 3:36 pm we picked up a Chevrolet Blazer (Arizona 611 ERB) as it entered through the East Fee Station and followed it back to the visitor center parking lot where it parked at approximately 4:33 pm. The vehicle made one long stop to allow the two children to take pictures. On both legs of the trip between the East gate traffic was stopped prior to the tunnels in order to accommodate one or more large RV. The park personnel stop traffic in both directions. The last vehicle allowed through in the opposing direction is given a baton, which upon exiting from the last tunnel, they give to the park ranger. In this way, the ranger knows the tunnel is clear and then allows the RV(s) and others waiting in line to proceed. Once the RV's have passed through the tunnels, two-way traffic is resumed. On the return trip, we noted approximately 30 vehicles were held up at our end of the tunnel until we were allowed to proceed. Engines appeared to be kept running during the delay. Upon inquiry regarding the number of times per day that an escort is required, the ranger at the East Fee Gate estimated the number at 200. Dave Sharrow felt that during the summer month's traffic was held up about 80 percent of the time and in the winter about 20 percent of the time.

We then set up the video camera and videotaped vehicles at the intersection of the park's main road and the turnoff to the visitors' center. We videotaped until approximately 5:30 pm. On the way out of the park, we stopped at a location where two gentlemen sell firewood out of the back of their pickup truck. They have apparently been doing this for several years. Their firewood is ponderosa pine that is packaged in what I would estimate to be 12 to 15 lb bundles. They said this year has been extremely bad for them. Last year they often sold 100 bundles per day. This year, they have only been selling 10 bundles per day. They feel the reasons for the downturn in their business may include: competition (others have begun to sell wood such as local stores), the park shuttle service from Springdale (now fewer cars pass by them), and the park no longer allows tubing in the river (although a private campground just outside of the park apparently still provides tubing opportunities).

We then traveled to St. George in order to purchase a stopwatch, a hand counter, printer paper, and 100 mb zip disks. After eating in St. George, we returned to the motel arriving around 10:30 pm.

August 17th

Following breakfast, had a short conversation with the restaurant cashier in which she indicated a dislike for the fact that the local residents are now required to use a shuttle bus if they wish to visit their own back yard. For that reason, she does not use the shuttle and will wait until after October to visit the park once the shuttle service has been discontinued.

Set up video camera at the intersection of the main road (just inside the park from the South fee collection kiosk) and the turnoff for the visitor center. This is the same location as we used the day before. We videotaped for two hours from 10-12 am. During that time, we counted a total of 852 vehicles, although, there were many double counts since some of the vehicles turning into the vehicle center were then recounted as they exited the visitor center and either left the park or continued on through the park.

We then followed a tour bus from Foremost Tours (1-800-871-7414) (license #CP50315 -California) from the above-described intersection to the East entrance. The bus driver pulled into the park museum building parking lot and the passengers got out for a restroom and picture-taking break. The bus's diesel engine was kept idling during this stop as well as during the other stops made on the trip through the park. I spoke with the driver and he told me he was heading the through the park and on to Bryce Canyon. The tour bus made one other picture-taking stop before reaching the tunnel. After the tunnel, no other stops were made. At the tunnel there was an 8-minute delay. We noted 16 cars were waiting at the other end of the tunnel as we came out. We again noted the elevation and odometer reading at the intersection of the turnoff for Zion Lodge (4070 ft, 577.7 mi.) and at the East entrance fee collection kiosk (5725 ft, 587.3mi), which yields an average slope of 172 feet per mile.

After turning around at the East entrance, we picked up a white Mazda MPV (California license plate 4JGM616) as it passed through the fee kiosk. The vehicle traveled without stopping until reaching the tunnel entrance where there were 14 cars and RV's waiting to go through. We waited for 5 minutes during which time at least 5 more vehicles arrived behind us. The driving pattern between the East entrance and the tunnel appeared to be a bit faster than we had experienced up to that time. After passing through the tunnel, the speed was dictated by the line of vehicles ahead of us. We believe the driving pattern (no stops, somewhat faster speed) was dictated by the need for one of the young female passengers to use a restroom facility. As soon as the vehicle reached the entrance to the South Campground, it turned in. While the driver was signing in at the sign-in shelter, a young girl jumped from the back of the car and ran quickly to the public restroom. After signing in, the driver drove the car to the restroom and everyone entered the facility. The adult female appeared to be suffering from a mild case of carsickness. Possibly from the curves coming down from the East entrance. It appeared they were going to stay at the campground for a while so we broke off contact at approximately 2:04 pm.

After lunch, we traveled to Virgin, Utah and took the Kolob Reservoir road. During that 3-hour trip, we observed a total of 41 vehicles (11 parked, 30 on road). Only 30 percent of the vehicles were passenger cars while the remaining 70 percent were pickup trucks or SUV's. There are several trailheads along this route. The road passes through two different sections of the park. In the cave valley area, there are a small number of private ranches. Between the park exit in Little Creek Valley and the Kolob reservoir, we counted at least 78 sites of habitation. These included what appeared to be year-round homes as well as seasonal homes, cabins, and trailers. In the area of the Kolob Mountain Ranch, there were signs indicating property was available on a subdivision basis. There were several other signs that this area is in a growth mode. Several of the homes/cabins appeared to be new construction. Over time, the Kolob reservoir road will probably undergo a gradual increase in vehicle usage. Of the vehicles noted traveling on the road, we would estimate 20 percent belonged to local residents. On the return trip, we took the turnoff to Lava Point where there are six campsites and a picnic area. There is also a vehicle trail, which travels the West Rim. Two campsites were occupied. The road to Lava Point is gravel although most of it is off the park property.

After supper, we surveyed the campgrounds to gather information on the number of campfires. We traveled through Loops A through E of the Watchman Campground as well as the South Campground. Of

the 189 occupied campsites we noted, 35 had campfires. We conducted the survey between 9:00 – 9:30 pm, which may be a little late since a number of the tent campers appeared to have already retired for the night. We will resurvey on Friday evening at an earlier time.

August 18th

On the way to the South entrance from the motel, noted one of the souvenir stores has bundled firewood for sale. It is bundled in the same type of red plastic netting as used by the fellows interviewed earlier this week.

Began day by videotaping vehicles parked in the visitor center parking lot. Then videotaped cars parked in the pullout areas on both sides of the turnoff for Zion Lodge. Tape is labeled as Zion 4818.

Set up camera at the NE end of the long tunnel. Tapes labeled Zion 4818 and Zion 5818. At that location, they keep a record of all the large vehicles traveling from East to Southwest. That information can be matched against the counter information at the East gate that records the total number of vehicles entering the park through that gate.

At approximately 2:05pm picked up a light blue Mercury Grand Marquis (Arizona license 635 BBS as it entered the park from the East entrance. The vehicle traveled to the Zion Lodge where it parked and the occupants went into the Lodge. Recorded as Zion0818-1. We walked through the parking lot and the lots where the lodge staffs' cars are located and videotaped the vehicles. (Believe this is contained on film Zion 6818). The lodge contains a dining room on the second floor and a gift shop. There is also a fast-food type of restaurant that contains a small pizza oven, a hot dog cooker, and some sort of a grill for hamburgers (couldn't see it). Also a small ice-cream shop.

Picked up a silver Chevy Blazer (California License 4LRF847) at South Gate. Driver was slowed by a bus for a short time then resumed his normal speed after the bus turned off. Tracked vehicles until it exited the park through the East Gate. Recorded as Zion0818-2.

Picked up a Black Chevy Cavalier (Missouri License 158 HKF) at the East entrance. They drove to the trailhead just above the upper entrance to the long tunnel. They then got out to hike the trail so we discontinued tracking at approximately 5:32 pm. Recorded as Zion 0818-3.

Picked up Green Plymouth Voyager (California License 3WLJ821) at the upper entrance to the long tunnel. Followed them down the hill until they passed the fee collection kiosk. Recorded as Zion0818-4.

At approximately 8pm we drove through the Watchman and South Campgrounds. Of the 225 camps we observed, 40 had campfires.

August 19th

Picked up a white Mitsubishi Montero Sport (Arizona License 227 EFF) at South entrance. The driver turned in at the South Campground entrance and proceeded toward the amphitheater. They then drove down the road to the side of the amphitheater building and then attempted to drive up a dirt path leading to the back of the building. They backed out and then drove out to the parking lot in front of the amphitheater. When we asked if they were lost, they just indicated they "just want to make a picnic." From the accent, they appeared to be a young Middle Eastern couple. They were near a picnic table and appeared ready to make their picnic. At that point, we dropped tracking them. Recorded as Zion0819-1.

We picked up a white Chevy Pickup (Nevada License 439 KDS) near the intersection to the visitors' center. At the first hairpin turn, it stopped and a fellow driving a Honda Accord parked next to them and got in their truck. They then drove to the parking area on the upper side of the long tunnel and began to unpack climbing gear. They said they were planning on doing some rappelling and then drive directly out

of the park when they finish. They indicated they use the park around two weekends a month. The driver is with the company that built the new visitor center. Recorded as Zion0819-2.

We then drove to the East entrance where we picked up a white Dodge 2500 pickup (Nevada License 444 EYS) as it entered the park. There was camping/hiking gear in the back along with two passengers plus the driver and passenger in the cab. They drove to the visitor center and parked. When asked about their plans for inside the park, they indicated they had dropped a group off at the Ranch at the east end of the Narrows and they are going to take a shuttle to the Temple of the Sinawava and then hike the Narrows until they meet the other group. We ended tracking at that point at approximately 9:08 a.m. Recorded as Zion0819-3.

At exit from visitor center we picked up a green Honda Odyssey (California License 3VVX814) traveling with a blue VW Jetta (California License 4AMD871). They stopped on a couple of occasions to take photos and to let their dogs out of the car. They exited the East gate and we discontinued tracking. Recorded as Zion0819-4.

Picked up a green Nissan Altima (California License 4KXS498) at the East fee booth. They stopped at the Checkerboard Mesa parking area to empty an ashtray. They then continued on to the pull out for the trailhead to the Canyon Overlook (just before the entrance to the long tunnel). We discontinued tracking at that point. Recorded as Zion 0819-5.

Departed Zion/Springdale area and traveled North on Interstate 15 to the entrance to Zion Kolob Canyon visitor center. It is a very small center. We let the people in the center know we were there and would be following vehicles around for the next several hours. They have a vehicle counter at the entrance and they do keep a manual count of the people entering the visitor center. They do not have a way of tracking the number vehicles that enter off the freeway only to use the restroom facilities and get rid of trash. We observed one vehicle doing this during our brief stay at the center. I looked at the manual log in the center. It appeared to be pretty consistent with 230-330 visitors per day being recorded. No special weekend pattern was discernible. The count information is sent to Zion headquarters on the 26 th of each month. We decided not to attempt a video survey of cars since they were pretty few and far between. From the 40 or so vehicles that we observed while at this end of the park, it appeared to us that there was a greater percentage of light duty vehicles than we had observed at the South end of the Park. Probably due to the proximity of this entrance to the freeway. We decided to follow a few vehicles to record their driving habits/patterns.

Picked up a white Pontiac Grand Am (Illinois License MFK 561) as it left the visitor center. We followed it up to the lookout at the end of the road. The occupants got out and hiked up the trail. Recorded as Zion0819-6.

While tracking the above vehicle, we noted the road is paved with patches of erosion entering onto the pavement. Evidence of grading of the erosion. Erosion creates some opportunity for particle entrainment. Road is in very good condition. It is asphalt covered with red volcanic cinders similar to the roads elsewhere in the Zion park (although in better condition – probably due to less usage).

We picked up a blue Dodge Neon (Utah License 233 LFJ) almost immediately after deciding to drop the Grand Am and continued to record as Zion0819-6. The Dodge Neon stopped at several viewpoints. We discontinued tracking them at one point thinking they were stopping to take a nap since the passenger reclined his/her seat. However, just as we shut the computer off, they started up again. So we started a new tracking file on them. They then continued on out of the park. The second part of their tracking is recorded as Zion0819-7.

We waited at the Kolob Canyon visitor center for another vehicle. We picked up a white Mitisubishi Diamante (Utah License 275 YYP). They stopped at the first trailhead turnout and appeared to start preparing lunch. We stopped tracking and pulled up the hill to the next turnout. Recorded as Zion0819-8.

Picked up a red Ford Blazer (Nevada License 568 KJU). After photo stops along the way, the single occupant drove to the lookout at the end of the road and parked. Discontinued tracking at this point. Recorded as Zion 0819-9.

Picked up the white Pontiac Grand Am we had originally started tracking as it departed the lookout point. They subsequently turned off at a parking point and we were unable to follow. We ended up not tracking them any further. Recorded as Zion0819-10.

At this point, we departed the North entrance and began the trip to Arches National Park.