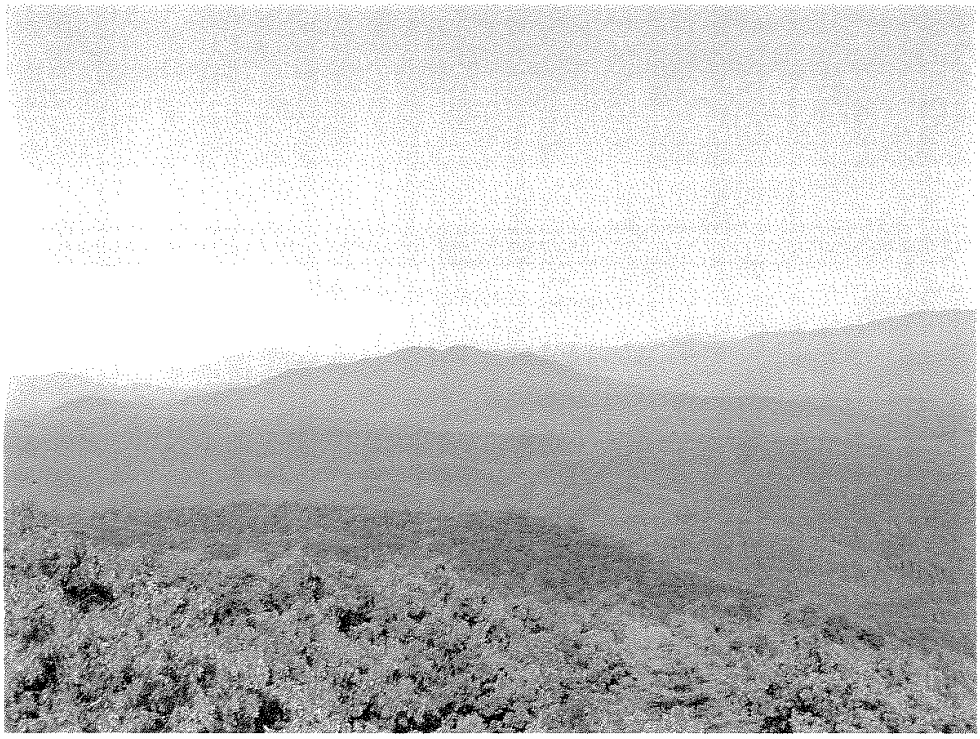
FINAL

2000 AIR EMISSIONS INVENTORY

GREAT SMOKY MOUNTAINS NATIONAL PARK
TENNESSEE/NORTH CAROLINA



U.S. NATIONAL PARK SERVICE

OCTOBER 2002

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GREAT SMOKY MOUNTAINS NATIONAL PARK
TENNESSEE/NORTH CAROLINA

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OCTOBER 2002

Cover Photo: View from Look Rock by NPS Web Cam

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1. INTRODUCTION

1.1 BACKGROUND

In August of 1999, the National Park Service (NPS) embarked on the Natural Resource Challenge, a major effort to substantially improve how the NPS manages the natural resources under its care. As part of Natural Resource Challenge, the NPS Air Resources Division (ARD) was tasked with the responsibility of expanding efforts to monitor and understand air quality and related values in the parks. In addition, the NPS Environmental Leadership policy directs the NPS to manage the parks in a manner "that demonstrates sound environmental stewardship by implementing sustainable practices in all aspects of NPS management...." In order to achieve both of these objectives, it is necessary to gain an understanding of air pollution emissions that result from activities within the park. Development of an in-park air emissions inventory for Great Smoky Mountains National Park (NP) serves three functions in this regard. First, it provides a baseline and an understanding of the sources and magnitude of in-park emissions and a basis for contrasting them with emissions from the surrounding area. Second, it identifies existing and potential strategies to mitigate in-park air emissions. Finally, it evaluates and ensures the compliance status of the park relative to state and federal air pollution regulations.

1.2 TYPICAL AIR EMISSION SOURCES

Typical air emission sources within NPS units include stationary, area, and mobile sources. Stationary sources can include fossil fuel-fired space and water heating equipment, generators, and fuel storage tanks. Area sources may include prescribed burning, woodstoves and fireplaces, campfires, and miscellaneous visitor activities. Mobile sources may include vehicles operated by visitors, tour operators, and NPS and concessionaire employees, and nonroard vehicles and equipment.

1.3 INVENTORY METHODOLOGY

The methodology to accomplish the air emissions inventory consisted of a site survey in March 2002, interviews with Great Smoky Mountains NP[1] and concessionaire personnel, review of applicable park records, emission calculations, and report preparation. The data were used in conjunction with a number of manual and computer software computational tools to calculate emissions. Computational tools included U.S. Environmental Protection Agency (USEPA) emission factors such as the Factor Information Retrieval System (FIRE) database, USEPA

[1] Jim Renfro, Great Smoky Mountains NP, Air Resource Specialist (865) 436-1708

TANKS 4.0 model, U.S. Forest Service *First Order Fire Effects Model (FOFEM) 4.0* model, and USEPA *MOBILE5b*and *PART5* mobile source emissions model. It should be noted that emissions are expected to vary from year to year due to fluctuations in visitation, prescribed and wildland fires, and other activities. Additional information on emission estimation methodology, including emission factors, are provided in Appendix A.

1.4 PARK DESCRIPTION

Great Smoky Mountains National Park, in the states of North Carolina and Tennessee (Figure 1), encompasses over 800 square miles or 521,490 acres of which 95 percent are forested. World renowned for the diversity of its plant and animal resources, the beauty of its ancient mountains, the quality of its remnants of Southern Appalachian mountain culture, and the depth and integrity of the wilderness sanctuary within its boundaries, it is one of the largest protected areas in the east. It was established as a National Park in 1934 and was designated an International Biosphere Reserve in 1976 and a World Heritage Site 1983. A map of the park is depicted in Figure 2.

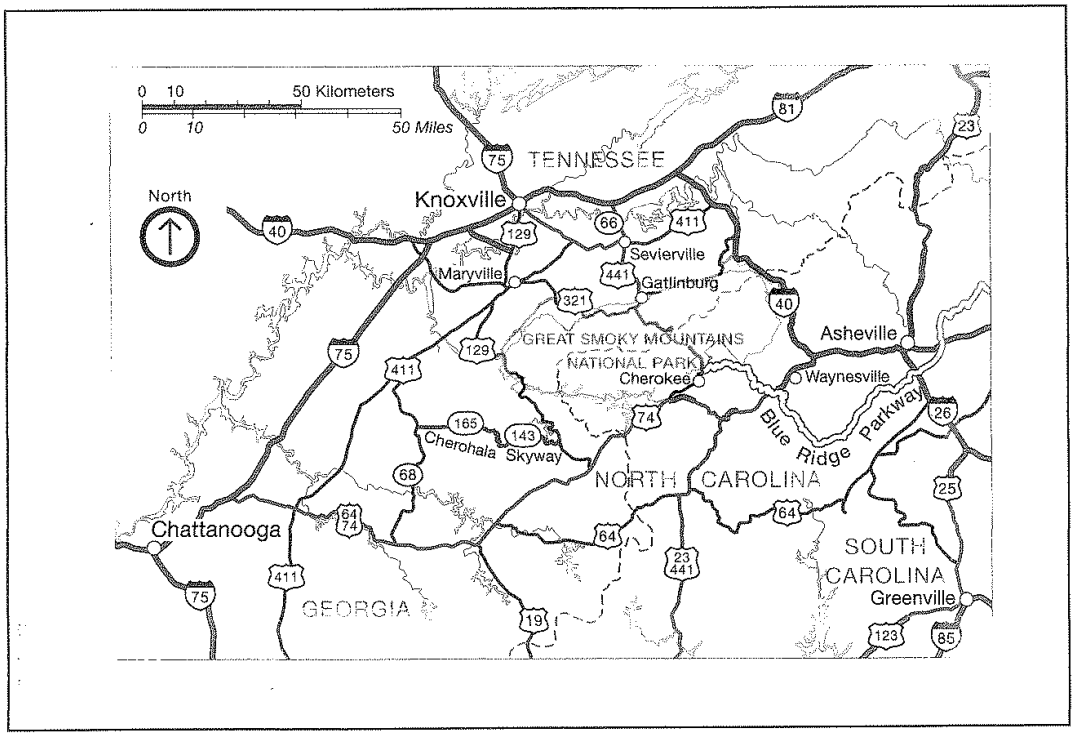

FIGURE 1. GREAT SMOKY MOUNTAINS NATIONAL PARK LOCATION

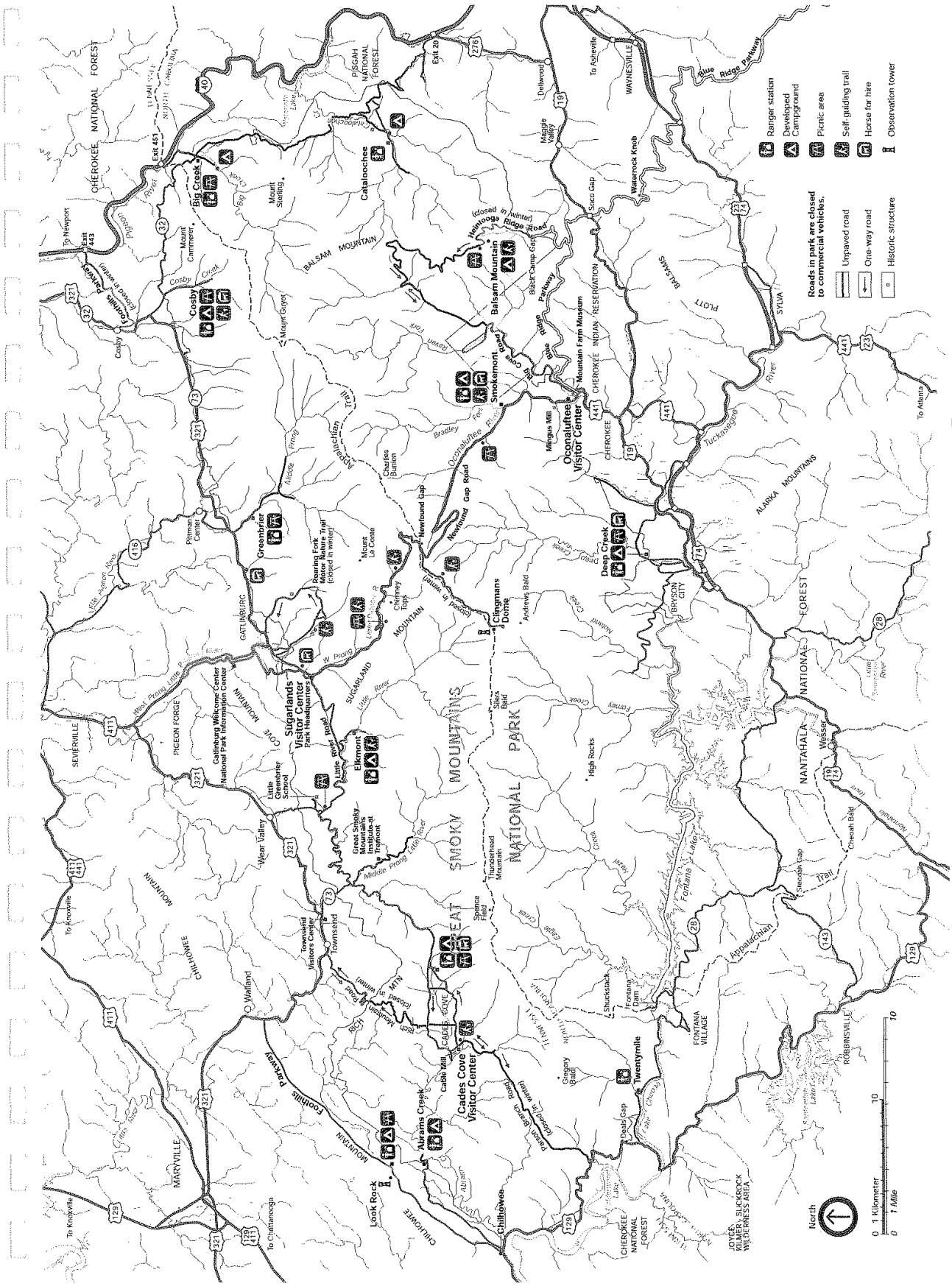

FIGURE 2. GREAT SMOKY MOUNTAINS NATIONAL PARK

Information on developed areas in the park is summarized in Table 1, and site maps of many of these developed areas are provided in Appendix B. The only lodging in the park are rustic cabins and lodge on top of Mount LeConte that can be reached only by hiking trails.

TABLE 1: GREAT SMOKY MOUNTAINS NP DEVELOPED AREAS

Name/Location	Function/Facilities
Sugarlands	Visitor Center, Park Headquarters, Maintenance Shops, Employee Housing
Twin Creeks	Natural Resources Center, Resource Management & Science Division
Cades Cove/Cable Mill	Visitor Center, Ranger Station, Maintenance Shop, Water Plant, Employee Housing
LeConte Lodge	Cabins and Lodge
Deep Creek	Seasonal Quarters, Ranger Station, Maintenance Shop
Look Rock	Maintenance Yard, Campgrounds, Picnic Area, Air Quality Station
Cataloochee	Ranger Station, Maintenance Yard
Oconaluftee	Visitor Center, Maintenance Yard, Employee Housing
Cosby	Campground, Ranger Station, Maintenance Yard
Oconaluftee Job Corps	Administrative Office, Dormitories, Dining Hall, Training Facility, Laundry, Dispensary, Gymnasium
Institute at Tremont	Administrative Offices, Dormitory, Dining Hall, Seasonal Apartments, Director's House
Campgrounds	See Section 2, Table 8

1.5 AIR QUALITY STATUS

Great Smoky Mountains NP is located in Blount, Sevier, and Cocke Counties, TN and Swain and Haywood Counties, NC. The Tennessee Department of Environment and Conservation and North Carolina Department of Environment and Natural Resources are the governing authorities for regulating air pollution. All the counties currently are classified as attainment for all the National Ambient Air Quality Standards (NAAQS); however, with the exception of Cocke County, TN, it has been recommended by the governors of Tennessee and North Carolina that the park be designated as nonattainment for the 8-hour ozone standard. Data from five ozone monitoring stations throughout the park indicate that the 8-hour ozone standard was exceeded for a peak of 52 days in 1999, which declined to 31 and 14 days in 2000 and 2001 days, respectively. However, data for 2002 indicate 43 exceedences up to October 2002. Information on the air quality monitoring sites, equipment, and data are provided in Appendix C.

Great Smoky Mountains NP is one of 49 NPS units that are designated as Class I areas by the Clean Air Act and its Amendments. A Class I area is one that receives the most stringent degree of air quality protection within and around its borders. For example, potential new or modified sources of significant pollution that plan to locate near a Class I area must obtain a permit from the applicable air quality regulatory agency. The NPS has significant input to the permitting process to ensure that potential air emissions do not pose a threat to visibility or other park air quality related values.

2. STATIONARY AND AREA SOURCE EMISSIONS

This section summarizes emissions from sources at Great Smoky Mountains NP for the year 2000. The discussion is divided into sections covering emissions from combustion sources, fuel storage sources, and area sources. The following emissions were calculated for each source: particulate matter (PM_{10}), sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs). Emission factors used in the calculations are provided in Appendix A.

2.1 STATIONARY SOURCES

2.1.1 Space And Water Heating Equipment

Stationary combustion sources at Great Smoky Mountains NP include No. 2 fuel oil and propane space and water heating units, and Table 2 provides an inventory of these heating units. Criteria air emissions were calculated using the appropriate residential and commercial unit emission factors. For example, PM emissions from a No. 2 fuel oil boiler at the Sugarlands Visitor Center are calculated as follows:

$$4{,}922\ gal/yr\ x \left[\frac{2.0\ lb\ PM}{1{,}000\ gal}\right] = 10\ lb\ PM/yr$$

Actual criteria pollutant emissions from space and water heating equipment are summarized in Table 3. Potential emissions also were calculated by assuming that the heating units were operated continuously during the year or 8,760 hours per year, and these emissions are summarized in Table 4.

TABLE 2: HEATING EQUIPMENT AT GREAT SMOKY MOUNTAINS NP

Location	Capacity (Btu/hr)	Number	Fuel Type
National Park Service			
Sugarlands Visitor Center	85,000	5	No. 2 fuel oil
Park Headquarters	1,000,000	1	No. 2 fuel oil
Twin Creeks Area	250,000	1	No. 2 fuel oil
Cades Cove Ranger Station	80,000	1	Propane
Cades Cove Maintenance Building	100,000	1	Propane
Cades Cove Maintenance Building	200,000	2	Propane
Cable Mill Visitor Center	80,000	1	Propane
Cable Mill Visitor Center	28,000	1	Propane
Cable Mill Comfort Station	100,000	1	Propane
Cable Mill Comfort Station	60,000	1	Propane
Cable Mill Sewer Building	28,000	1	Propane
Cable Mill Water Plant	28,000	1	Propane
Tremont Institute			
Dorm	120,000	4	Propane
Dorm	200,000	1	Propane
Kitchen	100,000	2	Propane
Kitchen	120,000	1	Propane
Office/Maintenance	125,000	1	Propane
Staff Quarters	60,000	1	Propane
Directors House	90,000	1	Propane

TABLE 3: 2000 ACTUAL CRITERIA EMISSIONS FROM HEATING EQUIPMENT AT GREAT SMOKY MOUNTAINS NP

Location	Fuel Type	Consumption (gal/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
National Park Service							
Sugarlands Visitor Center	No. 2 oil	4,922	10	35	98	25	2
Park Headquarters	No. 2 oil	11,582	23	82	232	58	4
Twin Creeks Area	No. 2 oil	2,896	1	21	52	14	2
No. 2 Oil Subtotal		19,400	34	138	382	97	8
Cades Cove Ranger Station	Propane	1,027	0	0	14	2	0
Cades Cove Maintenance Building	Propane	1,283	1	0	18	3	0
Cades Cove Maintenance Building	Propane	5,133	2	0	72	10	2
Cable Mill Visitor Center	Propane	1,027	0	0	14	2	0
Cable Mill Visitor Center	Propane	359	0	0	5	1	0
Cable Mill Comfort Station	Propane	1,283	1	0	18	3	0
Cable Mill Comfort Station	Propane	770	0	0	11	2	0
Cable Mill Sewer Building	Propane	359	0	0	5	1	0
Cable Mill Water Plant	Propane	359	0	0	5	1	0
Propane Subtotals		11,600	4	0	162	25	2
National Park Service Subtotals			38	138	544	122	10
Tremont Institute							
Dorm	Propane	6,162	2	0	86	12	2
Dorm	Propane	2,568	1	0	36	5	1
Kitchen	Propane	2,568	1	0	36	5	1
Kitchen	Propane	1,541	1	0	22	3	0
Office/Maintenance	Propane	1,605	1	0	22	3	0
Staff Quarters	Propane	770	0	0	11	2	0
Directors House	Propane	1,155	0	0	16	2	0
Tremont Institute Subtotals		16,369	7	0	229	33	5
		Totals	45	138	774	153	16

TABLE 4: 2000 POTENTIAL CRITERIA EMISSIONS FROM HEATING EQUIPMENT AT GREAT SMOKY MOUNTAINS NP

Location	Fuel Type	Consumption (gal/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
National Park Service							
Sugarlands Visitor Center	No. 2 oil	26,593	53	189	532	133	9
Park Headquarters	No. 2 oil	62,571	125	444	1,251	313	21
Twin Creeks Area	No. 2 oil	15,643	6	111	282	78	11
No. 2 Oil Subtotal		104,807	184	744	2,065	524	41
Cades Cove Ranger Station	Propane	7,659	3	0	107	15	2
Cades Cove Maintenance Building	Propane	9,574	4	0	134	19	3
Cades Cove Maintenance Building	Propane	38,295	15	0	536	77	11
Cable Mill Visitor Center	Propane	7,659	3	0	107	15	2
Cable Mill Visitor Center	Propane	2,681	1	0	38	5	1
Cable Mill Comfort Station	Propane	9,574	4	0	134	19	3
Cable Mill Comfort Station	Propane	5,744	2	0	80	11	2
Cable Mill Sewer Building	Propane	2,681	1	0	38	5	1
Cable Mill Water Plant	Propane	2,681	1	0	38	5	1
Propane Subtotal		86,547	35	0	1,212	173	26
National Park Service Subtotals			218	744	3,277	695	67
Tremont Institute							
Dorm	Propane	45,954	18	0	643	92	14
Dorm	Propane	19,148	8	0	268	38	6
Kitchen	Propane	19,148	8	0	268	38	6
Kitchen	Propane	11,489	5	0	161	23	3
Office/Maintenance	Propane	11,967	5	0	168	24	4
Staff Quarters	Propane	5,744	2	0	80	11	2
Directors House	Propane	8,616	3	0	121	17	3
Tremont Institute Subtotals		122,066	49	1	1,709	244	37
		Totals	268	745	4985	941	104

2.1.2 Generators

2.1.2.1 Generator Emissions – Actual

Emissions were calculated by multiplying the unit rating (kW) of the generators by an estimated annual run time (hr/yr) to get the kW-hr/yr, and the appropriate emission factors were then applied. For example, PM emissions from the two 45 kW generators at the Water Plant are calculated as:

$$45\,kW\ x\ 2\ units\left[\frac{3{,}650\ hours}{year}\right]x\left[\frac{1.34\ hp}{kW}\right]x\left[\frac{0.00220\ lb\ PM}{hp\text{-}hr}\right]=68\ lb\ PM/yr$$

Actual generator criteria emissions are summarized in Table 5.

2.1.2.2 Generator Emissions – Potential

Potential emissions were also calculated for the generators, and the same emission factors that were used to calculate the actual emissions were used to calculate these potential emissions. Potential criteria generator emissions also are summarized in Table 6.

2.1.3 Fuel Storage Tanks

Great Smoky Mountains NP has eight aboveground gasoline storage tanks, and information on these tanks is provided in Tables 7. Emissions from fuel storage tanks were calculated using the EPA *TANKS 4.0* model. The gasoline tanks are equipped with Phase I vapor emission controls that capture vapors displaced from the vapor space in the tank when it is refilled. Emissions associated with gasoline dispensing are accounted for in the mobile source model.

There are two basic types of VOC emissions from storage tanks: working losses and standing losses. Working losses are composed of both withdrawal and refilling loss emissions. Withdrawal loss emissions result from the vaporization of liquid fuel residue on the inner surface of tank walls as the liquid levels in the tank are decreased and air is drawn into the tank. Refilling losses refer to fuel vapor releases to the air during the process of refilling the tank as the liquid level in the tank increases and pressurizes the vapor space. Standing losses describe those tank emissions from the vaporization of the liquid fuel in storage due to changes in ambient temperatures. VOC losses are also a direct function of the annual product throughput or turnovers. VOC emissions from gasoline storage tanks are summarized in Tables 7.

TABLE 7: GREAT SMOKY MOUNTAINS NP GASOLINE STORAGE TANK EMISSIONS

Location	Number	Type	Volume (gal)	Throughput (gal/yr)	VOC (lbs/yr)
National Park Service North District					
Park Headquarters	2	AST	2,000	27,623	752
Park Headquarters	1	AST	1,000	13,811	416
Cosby Maintenance	1	AST	1,000	13,811	416
Cades Cove Maintenance					
Tank #1	1	AST	1,000	7,620	313
Tank #2	1	AST	1,000	2,825	278
Tank #3	1	AST	1,000	5,647	299
Look Rock Maintenance					
Tank #1	1	AST	1,000	2,450	276
Oconaluftee Maintenance					
Tank #1	1	AST	2,000	30,613	682
			Totals	104,400	3,432

TABLE 5: 2000 ACTUAL GREAT SMOKY MOUNTAINS NP GENERATOR CRITERIA EMISSIONS

Facility	Fuel	Number	Rating (kW)	Run Time (hrs/yr)	Output (kW-hr/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
Water Plant	Propane	2	45	3,650	328,500	68	596	1,554	379	85

TABLE 6: 2000 POTENTIAL GREAT SMOKY MOUNTAINS NP GENERATOR CRITERIA EMISSIONS

Facility	Fuel	Number	Rating (kW)	Run Time (hrs/yr)	Output (kW-hr/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
Water Plant	Propane	2	45	8,760	788,400	163	1,430	3,730	909	203

2.1.4 Wastewater Treatment Plants

There were no data available on wastewater treatment plants at Great Smoky Mountains NP.

2.2 AREA SOURCES

2.2.1 Woodstoves/Fireplaces

There are no woodstoves or fireplaces in Great Smoky Mountains NP.

2.2.2 Campfires

There are ten frontcountry campgrounds with about 900 campsites and about 100 in the backcountry in Great Smoky Mountains NP. These sites were occupied between 150 to 365 days a year, and it was estimated that approximately 50 percent had an evening or morning campfire at each site. Assuming that each campfire site consumes approximately 10 lbs of wood, air emissions from campsites in 2000 were calculated and are summarized in Table 8.

TABLE 8: 2000 GREAT SMOKY MOUNTAINS NP CAMPFIRE EMISSIONS

Location	Campfires	Fuel (tons/yr)	PM_{10} (lbs/yr)	SO_2 (lbs/yr)	NO_X (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
Abrams Creek	1,688	8	292	3	22	2,131	1,932
Balsam Mountain	3,450	17	597	7	45	4,357	3,950
Big Creek	1,350	7	234	3	18	1,705	1,546
Cades Cove	29,383	147	5,083	59	382	37,110	33,643
Calaloochee	3,038	15	525	6	39	3,836	3,478
Cosby	18,563	93	3,211	37	241	23,444	21,254
Deep Creek	9,660	48	1,671	19	126	12,201	11,061
Elkmont	28,050	140	4,853	56	365	35,427	32,117
Look Rock	2,310	12	400	5	30	2,918	2,645
Smokemont	25,915	130	4,483	52	337	32,731	29,673
Total	123,405	617	21,349	247	1,604	155,861	141,299
			tons/yr				
			10.67	0.12	0.80	77.93	70.65

2.2.3 Prescribed and Wildland Fires

Wildland fires are ignited naturally, usually by lightning and are typically suppressed, while prescribed fires are ignited intentionally in order to achieve fire management objectives. Prescribed burning is a land treatment process to accomplish natural resource management

objectives, including reducing the potential for destructive wildfires, eliminating excessive fuel buildup, controlling insects and disease, improving wildlife habitat and forage production, maintaining natural succession of plant communities, and restoring natural processes. Only prescribed burning emissions are considered as anthropogenic emissions; however, to the extent that prescribed burning is conducted to achieve ecological benefit, the emissions could be considered natural.

The First Order Fire Effects Model (FOFEM) was used to estimate emissions from prescribed fires. FOFEM is a computer program developed by the Intermountain Fire Sciences Lab, U.S. Forest Service to predict the effects of prescribed fire and wildfire in forests and rangelands throughout the U.S. In particular, it quantifies emissions of PM_{10}, $PM_{2.5}$, CH_4, and CO, which are summarized in Table 9 for prescribed fires only.

TABLE 9: AIR EMISSIONS FROM PRESCRIBED FIRES IN 2000 IN GREAT SMOKY MOUNTAINS NP IN 2000

Fire Name	Acres	PM_{10} (lbs/yr)	$PM_{2.5}$ (lbs/yr)	VOC[1] (lbs/yr)	CO (lbs/yr)
Cades Cove Fields	664	5,976	4,648	1,328	11,952
Ski Mtn Pile	4	436	371	212	4,496
Total	668	6,412	5,019	1,540	16,448

[1] As methane (CH_4)

It should be noted that annual variations in emissions from prescribed burning are dependent on the number of acres burned in a given year, and to a lesser extent on meteorological conditions.

2.2.4 Miscellaneous Area Sources

Miscellaneous area sources include food preparation, degreasers, paints and other surface coatings, lighter fluid consumption, consumer solvents, propane use by visitors in recreational vehicles, and highway maintenance, such as paving materials. However, few data on these activities and products were available.

2.3 SUMMARY OF STATIONARY AND AREA SOURCE EMISSIONS

Table 10 summarizes the stationary and area source emissions calculated above in a format that allows comparison between the various sources as well as providing totals for each pollutant or pollutant category under consideration.

TABLE 10: SUMMARY OF 2000 STATIONARY AND AREA SOURCE EMISSIONS AT GREAT SMOKY MOUNTAINS NP

Activity	Particulates		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr
Stationary Combustion Sources										
Space and Water Heating Units	45	0.02	138	0.07	774	0.39	153	0,08	16	<0.01
Generators	68	0.03	596	0.30	1,554	0.78	379	0.19	85	0.04
Gasoline Storage Tanks	--	--	--	--	--	--	--	--	3,432	1.72
Stationary Sources Subtotal	113	0.06	734	0.37	2,328	1.16	532	0.27	3,533	1.77
Area Sources										
Campfires	21,349	10.67	247	0.12	1,604	0.80	155,861	77.93	141,299	70.65
Prescribed Fires	6,412	3.21	--	--	--	--	16,448	8.22	1,540[1]	0.77[1]
Area Sources Subtotal	27,761	11.01	247	0.12	1,604	0.80	172,309	86.15	142,840	71.42
Totals										
	Particulates		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr
Totals without Prescribed Burning	21,462	10.73	981	0.49	3,932	1.97	156,393	78.20	144,832	72.42
Totals with Prescribed Burning	27,874	13.94	981	0.49	3,932	1.97	172,841	86.42	146,372	73.19

[1] As methane

3. MOBILE SOURCE EMISSIONS

This section summarizes emissions from mobile sources at Great Smoky Mountains NP for 2000. Mobile emission sources include highway and nonroad vehicles.

3.1 HIGHWAY VEHICLES

3.1.1 Visitor Vehicles

The park maintains statistics on the number of vehicles entering the park from the three principal entrances at Gatlinburg, Cherokee, and Townsend, as well as eleven outlying entrances. In order to calculate visitor vehicle miles traveled (VMT) for this analysis, a number of broad assumptions were made. For example, visitor studies indicate that approximately 50 percent of visitors travel to the Cades Cove area (University of Idaho, 1997). For this analysis, it was assumed that 50 percent of visitor vehicles entering from the three principal entrances traveled to Cades Cove and exited from the same entrance. The remaining 50 percent traveled through the park and exited from another principal entrance. The vehicles entering from the outlying areas were assumed to exit from the same outlying entrance. Vehicles operating on the East and West Foothills Parkway were assumed to travel its length one-way. These assumptions are summarized in Table 11.

TABLE 11: ESTIMATED VISITOR VEHICLE TRAVEL IN GREAT SMOKY MOUNTAINS NP

Entrance	Exit	Vehicles		Miles
		Summer	Winter	
Gatlinburg	Gatlinburg via Cades Cove	617,098	78,130	65
	Cherokee	617,098	78,130	34
Townsend	Townsend via Cades Cove	283,909	37,039	30
	Cherokee	283,909	37,039	52
Cherokee	Cherokee via Cades Cove	419,970	54,329	125
	Gatlinburg	419,970	54,329	34
Abrams Creek	Abrams Creek	48,835	6,738	2
Big Creek	Big Creek	37,398	5,160	2
Cataloochee	Cataloochee	39,980	5,516	10
Cherokee Orchard	Cherokee Orchard	43,799	6,043	2
Foothills Parkway East	Foothills Parkway East	230,866	31,855	15
Cosby	Cosby	26,220	3,618	5
Twentymile	Twentymile	1,981	273	1
Foothills Parkway West	Foothills Parkway West	144,683	19,963	5
Greenbrier	Greenbrier	92,030	12,698	6
Deep Creek	Deep Creek	106,743	14,728	2
Bryson City	Bryson City	23,866	47,663	2
	Total	3,438,355	493,251	

The majority of mobile source emissions can be categorized as either exhaust or evaporative emissions. Exhaust emissions are related to the combustion of fuel in the engine and include VOC, NO_X, CO, and PM_{10}. Exhaust emissions are dependent on a number of factors, including engine load, engine design and age, combustion efficiency, emissions equipment such as catalytic converters, and other factors. Evaporative emissions, which can occur while the vehicle is running or at rest, are related to the volatilization of fuel from vapor expansion, leaks and seepage, and fuel tank vapor displacement. Evaporative emissions are primarily dependent on daily temperature cycles and fuel volatility. In addition to vehicle exhaust, PM_{10} emissions also result from brake and tire wear, as well as the re-entrainment of dust from paved and unpaved roads (referred to as fugitive dust).

Emission factors produced by the USEPA MOBILE5b model were used in conjunction with VMT data in order to estimate mobile source emissions for VOC (both exhaust and evaporative), NO_X, and CO for visitor vehicles. Similarly, emission factors produced by the PART5 model were used in conjunction with VMT data to estimate PM_{10} emissions. MOBILE5b produces exhaust and evaporative emission factors for the following classes of vehicles: Light Duty Gasoline Vehicles (LDGV), Light Duty Gasoline Trucks 1 (LDGT1), Light Duty Gasoline Trucks 2 (LDGT2), Heavy Duty Gasoline Vehicles (HDGV), Light Duty Diesel Vehicles (LDDV), Light Duty Diesel Trucks (LDDT), Heavy Duty Diesel Vehicles (HDDV), and Motorcycles. It also produces a composite emission factor for all vehicles based on the vehicle VMT mix supplied to the model. Inputs to the model include average vehicle speed, vehicle VMT mix, annual mileage accumulation rates and registration distributions by age, inspection and maintenance (I/M) program information, fuel information, ambient temperature data, and others.

Both the MOBILE5b and PART5 models are typically used to support planning and modeling efforts in urban or regional areas and include default inputs suited for these applications. Therefore, it is suitable for applications over large, regional transportation networks. Application of the MOBILE5b model required the utilization of unique inputs that were representative of mobile source activity within the park. In particular, it was necessary to utilize unique inputs for the visitor vehicle VMT mix and the vehicle age distribution. The Center for Environmental Research and Technology within the College of Engineering at the University of California's Riverside Campus (CE-CERT) established park-specific vehicle fleet characterizations in developing air emission inventories for Zion National Park (CE-CERT, 2001). CE-CERT found that the distribution of vehicle ages in the park reflected a larger fraction of newer vehicles compared to the general vehicle population. The park-specific mix vehicle types and vehicle age

distribution developed by CE-CERT have been applied in the mobile modeling for Great Smoky Mountains NP.

In addition to park-specific age distribution, CE-CERT also developed park-specific modeling inputs for driving patterns that differ significantly from the default driving patterns typically used in mobile modeling, such as the Federal Test Procedure (FTP). In particular, they found that the FTP reflects both higher speeds and a wider range of speeds than observed in national parks. However, since the MOBILE5b model is not designed to readily incorporate unique driving pattern data, the default driving cycle remains the basis for the mobile source emission estimates provided here.

Other important mobile modeling inputs that can significantly affect mobile emission factors are the average speed, fuel characteristics, and I/M program parameters. The average speed input to the mobile model was 35 mph, fuel volatility was assumed to be Reid vapor pressure (RVP) 9, and reformulated gasoline (RFG) was not assumed to be present. Finally, I/M program inputs were not included since there are no I/M programs in the areas near the park.

In order to account for seasonal differences in mobile emissions, separate MOBILE5b runs were performed to produce emission factors for winter and summer. A composite emission factor for each season, reflecting a park specific VMT mix adapted from CE-CERT, served as the basis for mobile source emission estimates. Additional particulate emissions (or entrained road dust) from vehicles operating on paved roads in Great Smoky Mountains NP also were calculated based on VMT.

A summary of visitor vehicle emissions is provided in Table 14 at the end of this section.

3.1.2 NPS Highway Vehicles

Great Smoky Mountains NP operates a fleet of highway vehicles that are owned by the NPS, but no vehicles are leased from the General services Administration (GSA), which is a common practice among many NPS units. There were some data on the annual VMT for light-duty and heavy-duty trucks, and these data were extrapolated to the other vehicle categories for purpose of this analysis. A summary of NPS and concessionaire vehicles and their estimated annual mileage is provided in Table 12, and emissions are summarized in Table 14 at the end of this section.

TABLE 12: NPS ROAD VEHICLES AT GREAT SMOKY MOUNTAINS NP

Vehicle Type	Number	Annual Usage (mi/yr)
Light-Duty Gasoline Vehicles	29	145,000
Light-Duty Gasoline Trucks	165	495,000
Medium Duty Diesel Trucks	25	75,000
Heavy Duty Gasoline Vehicles	15	32,600

3.2 NPS NONROAD VEHICLES

The NPS also owns and operates nonroad motorized equipment that is used to maintain roads and grounds and for other purposes. There are records of the Great Smoky Mountains NP equipment inventory, and the larger pieces of equipment for which there are usage data are noted in Table 13. Emission factors from the USEPA nonroad emission database were used to calculate annual emissions, and it was assumed that each piece of equipment was operated approximately 100 hours per year. Estimated emissions are provided in Table 14.

TABLE 13: NPS NONROAD VEHICLES AT GREAT SMOKY MOUNTAINS NP

Vehicle Type	Number	Annual Usage (hrs/yr)
Tractors	13	1,300
Backhoe	9	900
Grader	4	400
Sweeper	4	400
Forklift	3	100
Roller/Compactor	1	100
Utility Vehicle	11	1,100
Riding Mower	7	700
Bobcat	1	100
Dozer	1	100
Chipper	3	100

3.3 SUMMARY OF MOBILE SOURCE EMISSIONS

Table 14 summarizes the mobile source emissions calculated above in a format that allows comparison between the various sources as well as providing totals for each pollutant or pollutant category under consideration.

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Grader	4	400
Sweeper	4	400
Forklift	3	100
Roller/Compactor	1	100
Utility Vehicle	11	1,100
Riding Mower	7	700
Bobcat	1	100
Dozer	1	100
Chipper	3	100

3.3 SUMMARY OF MOBILE SOURCE EMISSIONS

Table 14 summarizes the mobile source emissions calculated above in a format that allows comparison between the various sources as well as providing totals for each pollutant or pollutant category under consideration.

TABLE 14: SUMMARY OF 2000 MOBILE SOURCE EMISSIONS AT GREAT SMOKY MOUNTAINS NP

Activity	Particulates[1]		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr
Road Vehicles										
Visitor Vehicles	354,834[1]	157.10	--	--	368,436	184.22	3,468,631	1,734.32	372,217	186.11
NPS Road Vehicles	1,497[1]	0.75	--	--	1,738	0.87	14,649	7.32	1,512	0.76
Road Vehicle Emissions Subtotal	356,331	178.17	--	--	370,174	185.09	3,483,280	1,741.64	373,729	186.86
Nonroad Vehicles										
NPS Nonroad Vehicles	628	0.31	--	--	2,140	1.07	1,248	0.62	714	0.36
Totals										
Totals	Particulates[1]		Sulfur Dioxide		Nitrogen Oxides		Carbon Monoxide		VOCs	
	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr	lbs/yr	tons/yr
	356,959	178.48	--	--	372,314	186.16	3,484,520	1,742.26	374,443	187.22

[1] Includes exhaust PM_{10} and road dust

4. GREAT SMOKY MOUNTAINS NP AND REGIONAL EMISSIONS

4.1 GREAT SMOKY MOUNTAINS NP SUMMARY

A summary of Great Smoky Mountains NP emissions is provided in Table 15.

TABLE 15: ESTIMATED ANNUAL EMISSIONS FROM GREAT SMOKY MOUNTAINS NP

Source	PM_{10} (tons/yr)	SO_2 (tons/yr)	NO_X (tons/yr)	CO (tons/yr)	VOCs (tons/yr)
Point Sources					
Space and Water Heaters	0.02	0.07	0.39	0,08	<0.01
Generators	0.03	0.30	0.78	0.19	0.04
Gasoline Storage Tanks	--	--	--	--	1.72
Subtotal	0.06	0.37	1.16	0.27	1.77
Area Sources					
Campfires	10.67	0.12	0.80	77.93	70.65
Prescribed Burning	3.21	--	--	8.22	0.77[1]
Subtotal	11.01	0.12	0.80	86.15	71.42
Mobile Sources					
Road Vehicles	178.17	--	185.09	1,741.64	186.86
Nonroad Vehicles	0.31	--	1.07	0.62	0.36
Subtotal	178.48	--	186.16	1,742.26	187.22
Totals	189.55	0.49	188.12	1,828.68	260.41

[1] As methane

4.2 REGIONAL AIR EMISSIONS

Emission estimates for Blount, Cocke, and Sevier Counties, TN, Haywood and Swain Counties, NC, and the states of Tennessee and North Carolina were obtained from the 1999 National Emission Inventory (NEI) maintained by USEPA. It is important to note that differences may exist between the methodologies used to generate the park emission inventory and those used to generate the NEI. For example, here gasoline storage tanks have been included as stationary sources, while the NEI treats them as area sources. Table 16 provides a comparison of Great Smoky Mountains NP emissions with those from the surrounding counties and the two states. For all pollutants, Great Smoky Mountains NP emissions account for less than 1 percent of the surrounding county point and area source emissions.

TABLE 16: ESTIMATED ANNUAL EMISSIONS FROM GREAT SMOKY MOUNTAINS NP, SURROUNDING COUNTIES, AND THE STATES OF TENNESSEE AND NORTH CAROLINA

Area	PM_{10} (tons/yr)	SO_2 (tons/yr)	NO_X (tons/yr)	CO (tons/yr)	VOC (tons/yr)
Point Sources					
Great Smoky Mountains NP Total	<1	<1	1	<1	2
Blount County, TN	1,931	2,840	2,529	5,270	470
Cocke County, TN	86	203	188	28	10
Sevier County, TN	18	84	39	5	2
Haywood County, NC	164	7,550	3,791	2,236	75
Swain County, NC	--	15	2	<1	<1
Surrounding County Total	2,200	10,695	6,550	7,540	558
Tennessee	26,966	609,058	284,711	106,151	120,220
North Carolina	27,473	544,445	271,630	80,879	68,306
Tennessee/North Carolina Total	54,439	1,153,503	556,341	187,030	188,526
Area Sources					
Great Smoky Mountains NP Total	11	<1	<1	86	71
Blount County, TN	593	85	100	4,170	2,473
Cocke County, TN	349	34	46	2,342	1,161
Sevier County, TN	585	76	85	4,100	1,735
Haywood County, NC	650	90	59	4,391	1,979
Swain County, NC	228	19	22	1,561	540
Surrounding County Total	2,405	304	312	16,564	7,888
Tennessee	272,941	40,504	49,156	318,682	226,223
North Carolina	340,059	31,162	30,971	867,428	318,707
Tennessee/North Carolina Total	613,000	71,666	80,127	1,186,110	544,930
Mobile Sources					
Great Smoky Mountains NP Total	178	--	186	1,742	187
Blount County, TN	234	342	4,987	31,488	3,338
Cocke County, TN	115	140	2,603	13,291	1,566
Sevier County, TN	131	213	3,044	16,482	1,693
Haywood County, NC	171	234	4,150	17,956	1,950
Swain County, NC	32	48	568	2,931	351
Surrounding County Total	683	977	15,352	82,148	8,898
Tennessee	111,674	36,420	406,655	1,879,125	202,336
North Carolina	171,063	32,259	373,528	2,208,120	248,798
Tennessee/North Carolina Total	282,737	68,679	780,183	4,087,245	451,134

Finally, estimated emissions from the eight states that constitute Region 4 and those from the United States are summarized in Table 17.

TABLE 17: ESTIMATED 1999 EMISSIONS FROM REGION 4 AND THE U.S.

Area	PM_{10} (tons/yr)	SO_2 (tons/yr)	NO_X (tons/yr)	CO (tons/yr)	VOC (tons/yr)
Point Sources					
Tennessee	26,966	609,058	284,711	106,151	120,220
North Carolina	27,473	544,445	271,630	80,879	68,306
South Carolina	9,570	272,578	136,304	66,773	49,525
Kentucky	26,148	698,840	344,319	75,615	63,760
Georgia	39,711	594,918	242,933	178,368	36,050
Mississippi	10,226	164,064	158,352	90,578	43,430
Alabama	46,634	665,668	285,896	207,527	96,960
Florida	23,225	820,475	373,354	74,422	27,154
Region 4 Totals	209,953	4,370,046	2,097,499	880,313	505,405
United States	1,111,756	16,296,167	9,037,572	5,307,982	2,061,167
Area Sources					
Tennessee	272,941	40,504	49,156	318,682	226,223
North Carolina	340,059	31,162	30,971	867,428	318,707
South Carolina	93,467	13,868	136,304	66,773	49,525
Kentucky	146,687	54,855	70,723	169,936	129,203
Georgia	307,592	5,681	64,864	1,316,334	248,555
Mississippi	180,140	71,135	52,021	442,300	142,759
Alabama	158,799	43,682	63,506	628,610	151,317
Florida	204,469	38,115	61,110	979,936	376,167
Region 4 Totals	1,704,154	299,002	528,655	4,789,999	1,642,456
United States	9,734,269	1,289,884	2,251,929	16,972,636	7,574,071
Mobile Sources					
Tennessee	111,674	36,420	406,655	1,879,125	202,336
North Carolina	171,063	32,259	373,528	2,208,120	248,798
South Carolina	201,778	16,156	218,302	1,360,805	152,338
Kentucky	122,815	31,733	280,317	1,262,003	137,257
Georgia	520,615	35,260	453,921	2,810,844	288,475
Mississippi	219,254	14,662	194,181	1,013,591	127,336
Alabama	320,076	20,540	285,785	1,733,273	197,263
Florida	341,205	65,103	678,983	4,808,725	543,028
Region 4 Totals	2,008,480	252,133	2,891,672	17,076,486	1,896,831
United States	12,831,958	1,299,342	14,105,483	75,151,535	8,536,092

5. COMPLIANCE AND RECOMMENDATIONS

5.1 COMPLIANCE

The Tennessee Department of Environment and Conservation (TNDEC) and North Carolina Department of Environment and Natural Resources (NCDENR) are the governing authorities for regulating air pollution. Park personnel should continue to coordinate with the agency on permit issues relating to stationary sources, as well as prescribed burning activities. Prior to replacing or adding relatively large heating units, generators, and fuel storage tanks, the appropriate agency should be consulted regarding the need to obtain a permit to construct or a permit to operate such sources. For example, North Carolina Air Quality Rule 15A NCAC 2Q.102 (c) exempts the following from permit requirements:

- liquid or gas fueled space heaters used solely for comfort heat
- residential woodstoves, heaters, or fireplaces
- hot water heaters used for domestic purposes only.

Both states also have exemptions to open burning regulations that apply to visitor activities in the park. The Rules of Tennessee DEC Chapter 1200-3-4-04 exempts "fires used for cooking of food or for ceremonial, recreational, or comfort-heating purposes, including barbecues, campfires, and outdoor fireplaces." North Carolina Air Quality Rule 15A NCAC 2D.1903(a)(3) exempts "campfires and fires used solely for outdoor cooking and other recreational purposes or for ceremonial occasions or for human warmth and comfort and which do not create a nuisance and do not use synthetic materials or refuse or salvageable materials for fuel."

With respect to visible emissions, Tennessee DEC Chapter 1200-3-5.01 limits visible emissions from any contaminant source to an opacity of 20 percent or less. NC Rule 15A NCAC 2D.D521 limits 01 limits visible emissions from sources manufactured after 1971 to an opacity of 20 percent or less, and 40 percent for sources manufactured after 1971. Measures to prevent the creation of fugitive dust also must be taken. For example, Tennessee DEC Chapter 1200-3-8-.01 requires that persons handling, transporting, or storing materials take reasonable precautions to prevent particulate matter from becoming airborne.

5.2 RECOMMENDATIONS

Actions to promote sustainable development in the design, retrofit, and construction of park facilities have associated air quality benefits. These include actions that reduce or replace consumption of conventional fossil fuels and/or reduce the consumption of other resources.

Reductions in potable and non-potable water consumption also achieve concurrent reductions in energy consumption and associated air emissions. Acquisition of energy efficient appliances whenever possible also is an incremental energy saving measure that has associated air quality benefits.

Opportunities to reduce NO_X and VOC emissions, which are the precursors for ozone formation, in Great Smoky Mountains NP are related to the reduction or replacement of conventional fossil fuels. The park has several photovoltaic power units in operation. These include four radio repeaters on Webb, Shuckstack, and Spur Mountains and Clingmans Dome and a unit to power air quality monitoring equipment on Clingmans Dome. The park, in conjunction with the Tennessee Valley Authority, also has a solar hot water heater at the Sugarlands Visitor Center.

Vehicle emissions are the largest source of emissions in the park. One current investigation is directed at reducing visitor vehicle congestion and associated emissions. The park is participating with the Knoxville Regional Transportation Planning Organization to undertake a Development Concept and Transportation Management Plan for Cades Cove. The Plan will result in a range of alternatives that provide for a comprehensive, long-range approach for managing the natural and cultural resources and improving the quality of visitor experience by providing for greater visitor mobility through a variety of transportation initiatives.

The park has undertaken a project to demonstrate the feasibility of electric vehicles in the Cades Cove and other areas. These vehicles include three John Deere Electric Gators, and Electric tractor "Ox", three Global Electric Motor Cars, four Club Car Carryalls, and three ZAPWorld Electric Bikes (EPRI, 2002). The project will run until March 2003 and will gather baseline fuel use and emission information, identify applicable and feasible electric vehicles, perform an energy efficiency study, and assess supporting infrastructure.

The park is also investigating the use of low sulfur gasoline and diesel fuels and biodiesel fuel for use in its vehicles. An analysis of the emission reductions possible with these fuels are summarized in Table 17. Although these reductions would be minor if such fuels were used by park vehicles only, significant reductions may be possible if these fuels were widely available in the surrounding communities for use by the general public.

TABLE 18: ESTIMATED EMISSIONS WITH LOW SULFUR/BIODIESEL VEHICLE FUELS

Fuel	Percent Reduction				
	PM_{10}	SO_2	NO_X	CO	VOC
Low Sulfur Gasoline[1]	-13	-88	-11	-15	-16
Low Sulfur Diesel[2]	-9	-97	0	0	0
Biodiesel (20% biomass based oil)	-18	-100	+1	-12.5	-11
	Emissions (tons/yr)				
Regular Gasoline/Regular Diesel	0.03	0.055	1.51	5.30	0.32
Low Sulfur Gasoline[1]/Low Sulfur Diesel[2]	0.03	<0.01	1.47	4.52	0.27
Low Sulfur Gasoline[1]/Biodiesel	0.03	<0.03	1.49	4.50	0.27

[1] 30 ppmw (Tier 2 gasoline rule) versus 300 ppmw

[2] 15 ppmw (proposed diesel sulfur rule) versus 500 ppmw

6. REFERENCES

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APPENDIX A

- FUEL DATA AND EMISSION FACTORS -

FUEL DATA

Fuel	Heating Value	Sulfur Content
No. 2 Distillate Fuel Oil/Diesel	140,000 Btu/gal	0.05% by weight
Natural Gas	1,050 Btu/ft^3	2,000 grains/10^6 ft^3
Propane	91,500 Btu/gal	0.18 grains/100 ft^3

STATIONARY SOURCE EMISSION FACTORS - BOILERS/HEATING UNITS

DISTILLATE OIL (DF-2) - CRITERIA POLLUTANTS					
Combustor Type	Emission Factor (lb/1,000 gal fuel burned)				
	PM[a]	SO_2[b]	NO_x[c]	CO	VOC[d]
Residential Furnace[e]	0.4	142S	18	5	0.713
Boilers < 100 Million Btu/hr (Commercial/Institutional Combust.[f])	2	142S	20	5	0.34
Boilers < 100 Million Btu/hr (Industrial Boilers[g])	2	142S	20	5	0.2
Boilers > 100 Million Btu/hr (Utility Boilers[h])	2	157S	24	5	--
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Tables 1.3-1 and 1.3-3.					

NATURAL GAS - CRITERIA POLLUTANTS					
Combustor Type (MMBtu/hr Heat Input)	Emission Factor (lb/10^6 ft^3 fuel burned)				
	PM[j]	SO_2	NO_x[c]	CO	VOC
Residential Furnaces (<0.3)					
-Uncontrolled	7.6	0.6	94	40	5.5
Tangential-Fired Boilers (All Sizes)					
-Uncontrolled	7.6	0.6	170	24	5.5
-Controlled-Flue gas recirculation	7.6	0.6	76	98	5.5
Small Boilers (<100)					
-Uncontrolled	7.6	0.6	100	84	5.5
-Controlled-Low NO_x burners	7.6	0.6	50	84	5.5
-Controlled-Low NO_x burners/Flue gas recirculation	7.6	0.6	32	84	5.5
Large Wall-Fired Boilers (>100)					
-Uncontrolled (Pre-NSPS)[k]	7.6	0.6	280	84	5.5
-Uncontrolled (Post-NSPS)[k]	7.6	0.6	190	84	5.5
-Controlled-Low NO_x burners	7.6	0.6	140	84	5.5
-Controlled-Flue gas recirculation	7.6	0.6	100	84	5.5
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Tables 1.4-1 and 1.4-2.					

STATIONARY SOURCE EMISSION FACTORS - BOILERS/HEATING UNITS (Continued)

PROPANE (LPG) - CRITERIA POLLUTANTS					
Combustor Type	Emission Factor (lb/1,000 gal fuel burned)				
	PM[a]	SO_2[b]	NO_x[c]	CO	VOC[d]
Commercial Boilers[f]	0.4	0.10S	14	1.9	0.3
Industrial Boilers[g]	0.6	0.10S	19	3.2	0.3
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 1.5-1.					

STATIONARY SOURCE EMISSION FACTORS - GENERATORS

For generators rated at less than or equal to 448 kW (600 hp):

Fuel Type	Emission Factor (lb/hp-hr)				
	PM	SO_x	NO_x	CO	VOC
DF-2	2.20 E-03	2.05 E-03	0.031	6.68 E-03	2.51 E-03
Gasoline	7.21 E-04	5.91 E-04	0.011	0.439	0.022
Natural Gas/Propane	1.54 E-04	7.52 E-03(S)	3.53 E-03	8.6 E-04	1.92 E-04
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 3.3-1 and 3.1-1					

For generators rated at greater than 448 kW (600 hp):

Fuel Type	Emission Factor (lb/hp-hr)				
	PM	SO_x[b]	NO_x	CO	VOC
DF-2	0.0007	(8.09 E-03)S	0.024	5.5 E-03	6.4 E-04
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 3.4-1.					

FIREPLACE EMISSION FACTORS

Fuel Type	Emission Factor (lb/ton)				
	PM[j]	SO_x	NO_x[c]	CO	VOC
Wood	34.6	0.4	2.6	252.6	229.0
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 1.9-1.					

WOODSTOVE EMISSION FACTORS

Stove Type	Emission Factor (lb/ton)				
	PM[(j)]	SO_x	NO_x[(c)]	CO	VOC
Conventional	30.6	0.4	2.8	230.8	53
Noncatalytic	19.6	0.4	--	140.8	12
Catalytic	20.4	0.4	2.0	104.4	15
Source: AP-42, 5th Edition, Supplements A, B, C, D, and E, Table 1.10-1.					

STATIONARY SOURCE EMISSION FACTORS - SURFACE COATING OPERATIONS

Surface Coating Type	VOC Emission Factor (lb/gal)
Paint: Solvent Base	5.6
Paint: Water Base	1.3
Enamel: General	3.5
Lacquer: General	6.1
Primer: General	6.6
Varnish/Shellac: General	3.3
Thinner: General	7.36
Adhesive: General	4.4
Source: *Calculation Methods for Criteria Air Pollutant Emission Inventories*, AL/OE-TR-1994-0049, July 1994. Armstrong Laboratory.	

(a) PM = Filterable Particulate Matter.
(b) These factors must be multiplied by the fuel sulfur content (for example, if the sulfur content is 0.05%, then S equals 0.05).
(c) Expressed as NO_2.
(d) Emission factors given in AP-42 are actually for non-methane total organic compounds (NMTOC) which includes all VOCs and all exempted organic compounds (such as ethane, toxics and HAPs, aldehydes and semivolatile compounds) as measured by EPA reference methods.
(e) Unit Rating <300,000 Btu/hr.
(f) Unit Rating ∃300,000 Btu/hr, but <10,000,000 Btu/hr.
(g) Unit Rating ∃10,000,000 Btu/hr, but <100,000,000 Btu/hr.
(h) Unit Rating ∃100,000,000 Btu/hr.
(i) POM = Particulate POM only.
(j) PM = Filterable Particulate Matter + Condensible Particulate Matter.
(k) NSPS = New Source Performance Standard as defined in 40 CFR 60 Subparts D and Db. Post-NSPS units are boilers with greater than 250 MMBtu/hr of heat input that commenced construction, modification, or reconstruction after August 17, 1971, and units with heat input capacities between 100 and 250 MMBtu/hr that commenced construction, modification, or reconstruction after June 19, 1984.
(l) Emission factors are given on a fuel input basis (lb/MMBtu). To convert to a power output basis (lb/hp-hr), use an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr.

2000 ACTUAL CRITERIA EMISSIONS FROM HEATING UNITS AT GREAT SMOKY MOUNTAINS NP

Emission Source	Location	Fuel	Number of Sources	Capacity (Btu/hr)		Consumption (gal/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_X (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
National Park Service											
Furnace	Sugarlands Visitor Center	No. 2 Fuel Oil	5	85,000	425,000	4,922	10	35	98	25	2
Boiler	Sugarlands Park Headquarters	No. 2 Fuel Oil	1	1,000,000	1,000,000	11,582	23	82	232	58	4
Boiler	Twin Creeks Administration	No. 2 Fuel Oil	1	250,000	250,000	2,896	1	21	52	14	2
		Totals	7	1,335,000	1,675,000	19,400	34	138	382	97	8
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for residential furnaces (<300,000 Btu/hr)							0.4	142S	18.0	5.0	0.7
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for furnaces (>300,000 Btu/hr)							2.0	142S	20.0	5.0	0.3
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)											
Heater	Cades Cove Ranger Station	Propane	1	80,000	80,000	1,027	0	0	14	2	0
Heater	Cades Cove Maintenance Building	Propane	1	100,000	100,000	1,283	1	0	18	3	0
Ceiling Heater	Cades Cove Maintenance Building	Propane	2	200,000	400,000	5,133	2	0	72	10	2
Fireplace	Cable Mill Visitor Center	Propane	1	80,000	80,000	1,027	0	0	14	2	0
Wall Heater	Cable Mill Visitor Center	Propane	1	28,000	28,000	359	0	0	5	1	0
Water Heater	Cable Mill Comfort Station	Propane	1	100,000	100,000	1,283	1	0	18	3	0
Heater	Cable Mill Comfort Station	Propane	1	60,000	60,000	770	0	0	11	2	0
Heater	Cable Mill Sewer Building	Propane	1	28,000	28,000	359	0	0	5	1	0
Wall Heater	Cable Mill Water Plant	Propane	1	28,000	28,000	359	0	0	5	1	0
		Totals	10		904,000	11,600	5	0	162	23	3
Tremont Institute											
Heating Unit	Dorm	Propane	4	120,000	480,000	6,162	2	0	86	12	2
Water Heater	Dorm	Propane	1	200,000	200,000	2,568	1	0	36	5	1
Heating Unit	Kitchen	Propane	2	100,000	200,000	2,568	1	0	36	5	1
Heating Unit	Kitchen	Propane	1	120,000	120,000	1,541	1	0	22	3	0
Heating Unit	Office/Maintenance	Propane	1	125,000	125,000	1,605	1	0	22	3	0
Heating Unit	Staff Quarters	Propane	1	60,000	60,000	770	0	0	11	2	0
Water Heater	Directors House	Propane	1	90,000	90,000	1,155	0	0	16	2	0
		Totals	11		1,275,000	16,368	7	0	229	33	5
Emission Factors from AP-42, Tables 1.5-1 for commercial boilers, S=.05							0.4	0.01	14.00	1.90	0.30
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)											
		Total Heating Units	28				45	138	774	153	16

2000 POTENTIAL CRITERIA EMISSIONS FROM HEATING UNITS AT GREAT SMOKY MOUNTAINS NP

Emission Source	Location	Fuel	Number of Sources	Capacity (Btu/hr)		Consumption (gal/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_X (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
National Park Service											
Furnace	Sugarlands Visitor Center	No. 2 Fuel Oil	5	85,000	425,000	26,593	53	189	532	133	9
Boiler	Sugarlands Park Headquarters	No. 2 Fuel Oil	1	1,000,000	1,000,000	62,571	125	444	1,251	313	21
Boiler	Twin Creeks Administration	No. 2 Fuel Oil	1	250,000	250,000	15,643	6	111	282	78	11
		Totals	7	1,335,000	1,675,000	104,807	185	744	2,065	524	41
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for residential furnaces (<300,000 Btu/hr)							0.4	142S	18.0	5.0	0.7
Emission Factors from AP-42, Tables 1.3-1 and 1.3-3 for furnaces (>300,000 Btu/hr)							2.0	142S	20.0	5.0	0.3
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)											
Heater	Cades Cove Ranger Station	Propane	1	80,000	80,000	7,659	3	0	107	15	2
Heater	Cades Cove Maintenance Building	Propane	1	100,000	100,000	9,574	4	0	134	19	3
Ceiling Heater	Cades Cove Maintenance Building	Propane	2	200,000	400,000	38,295	15	0	536	77	11
Fireplace	Cable Mill Visitor Center	Propane	1	80,000	80,000	7,659	3	0	107	15	2
Wall Heater	Cable Mill Visitor Center	Propane	1	28,000	28,000	2,681	1	0	38	5	1
Water Heater	Cable Mill Comfort Station	Propane	1	100,000	100,000	9,574	4	0	134	19	3
Heater	Cable Mill Comfort Station	Propane	1	60,000	60,000	5,744	2	0	80	11	2
Heater	Cable Mill Sewer Building	Propane	1	28,000	28,000	2,681	1	0	38	5	1
Wall Heater	Cable Mill Water Plant	Propane	1	28,000	28,000	2,681	1	0	38	5	1
		Totals	10		904,000	86,547	35	0	1,212	173	26
Tremont Institute											
Heating Unit	Dorm	Propane	4	120,000	480,000	45,954	18	0	643	92	14
Water Heater	Dorm	Propane	1	200,000	200,000	19,148	8	0	268	38	6
Heating Unit	Kitchen	Propane	2	100,000	200,000	19,148	8	0	268	38	6
Heating Unit	Kitchen	Propane	1	120,000	120,000	11,489	5	0	161	23	3
Heating Unit	Office/Maintenance	Propane	1	125,000	125,000	11,967	5	0	168	24	4
Heating Unit	Staff Quarters	Propane	1	60,000	60,000	5,744	2	0	80	11	2
Water Heater	Directors House	Propane	1	90,000	90,000	8,616	3	0	121	17	3
		Totals	11		1,275,000	122,066	49	1	1,709	244	37
Emission Factors from AP-42, Tables 1.5-1 for commercial boilers, S=.05							0.4	0.01	14.00	1.90	0.30
Formula = Consumption (gal/yr) * Emission Factor (lb/1,000 gal)											
		Total Heating Units	18				268	745	4985	941	104

2000 ACTUAL CRITERIA EMISSIONS FROM GENERATORS AT GREAT SMOKY MOUNTAINS NP

Emission Source	Location	Fuel	Number of Sources	Rating (kW)	Run Time (hrs/yr)	Output (kW-hr/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
National Park Service											
Generator	Water Plant	Propane	2	45	3,650	328,500	68	596	1,554	379	85
	Propane Generator Totals		2	45	3,650	328,500	68	596	1,554	379	85
Emission Factors from AP-42, Chapter 3.1-1 for natural gas large uncontrolled gas turbines (lb/hp-hr), S=.1 Formula = Emission Factor (lb/hp-hr) * 608 (g/kW-hr / lb/hp-hr) * Output (kW-hr/yr) / 453.6 (g/lb)							1.54E-04	7.52E-03*S	3.53E-03	8.60E-04	1.92E-04
						Park Totals (tons/yr)	0.03	0.30	0.78	0.19	0.04

2000 POTENTIAL CRITERIA EMISSIONS FROM GENERATORS AT GREAT SMOKY MOUNTAINS NP

Emission Source	Location	Fuel	Number of Sources	Rating (kW)	Run Time (hrs/yr)	Output (kW-hr/yr)	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
National Park Service											
Generator	Medical Clinic	Propane	2	45	8,760	788,400	163	1,430	3,730	909	203
		Propane Generator Totals	2	45	8,760	788,400	163	1,430	3,730	909	203
Emission Factors from AP-42, Chapter 3.1-1 for natural gas large uncontrolled gas turbines (lb/hp-hr), S=.18							1.54E-04	7.52E-03*S	3.53E-03	8.60E-04	1.92E-04
Formula = Emission Factor (lb/hp-hr) * 608 (g/kW-hr / lb/hp-hr) * Output (kW-hr/yr) / 453.6 (g/lb)											
						Park Totals (tons/yr)	0.08	0.72	1.87	0.45	0.10

TANKS 4.0
Emissions Report - Summary Format
Tank Identification and Physical Characteristics

Identification

User Identification:	GRSM Headquaters
City:	Knoxville
State:	Tennessee
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	Tank #1

Tank Dimensions

Shell Length (ft):	12.00
Diameter (ft):	5.25
Volume (gallons):	2,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	27,623.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Medium
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Knoxville, Tennessee (Avg Atmospheric Pressure = 14.25 psia)

GRSM Headquaters
NPS

Horizontal Tank
Knoxville, Tennessee

TANKS 4.0
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 8)	All	66.48	56.03	76.93	60.63	4.5963	3.7327	5.6139	68.0000			92.00	Option 4: RVP=8, ASTM Slope=3

TANKS 4.0
Emissions Report - Summary Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 8)	205.56	546.61	752.17

TANKS 4.0
Emissions Report - Summary Format
Tank Identification and Physical Characteristics

Identification

User Identification:	GRSM Headquarters
City:	Knoxville
State:	Tennessee
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	Tank #2

Tank Dimensions

Shell Length (ft):	10.75
Diameter (ft):	4.00
Volume (gallons):	1,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	13,811.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Medium
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Knoxville, Tennessee (Avg Atmospheric Pressure = 14.25 psia)

GRSM Headquarters
NPS

Horizontal Tank
Knoxville, Tennessee

TANKS 4.0
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 8)	All	66.48	56.03	76.93	60.63	4.5963	3.7327	5.6139	68.0000			92.00	Option 4: RVP=8, ASTM Slope=3

GRSM Headquarters
NPS

Horizontal Tank
Knoxville, Tennessee

TANKS 4.0
Emissions Report - Summary Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 8)	102.78	313.35	416.13

TANKS 4.0
Emissions Report - Summary Format
Tank Identification and Physical Characteristics

Identification

User Identification:	Cades Cove Maintenance
City:	Knoxville
State:	Tennessee
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	Tank #1

Tank Dimensions

Shell Length (ft):	10.75
Diameter (ft):	4.00
Volume (gallons):	1,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	7,620.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Light
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Knoxville, Tennessee (Avg Atmospheric Pressure = 14.25 psia)

Cades Cove Maintenance
NPS

Horizontal Tank
Knoxville, Tennessee

TANKS 4.0
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 8)	All	64.53	55.39	73.67	59.79	4.4237	3.6845	5.2780	68.0000			92.00	Option 4: RVP=8, ASTM Slope=3

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TANKS 4.0
Emissions Report - Summary Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 8)	54.58	258.11	312.68

TANKS 4.0
Emissions Report - Summary Format
Tank Identification and Physical Characteristics

Identification

User Identification:	Cades Cove Maintenance1
City:	Knoxville
State:	Tennessee
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	Tank #2

Tank Dimensions

Shell Length (ft):	10.75
Diameter (ft):	4.00
Volume (gallons):	1,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	2,825.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Light
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Knoxville, Tennessee (Avg Atmospheric Pressure = 14.25 psia)

TANKS 4.0
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 8)	All	64.53	55.39	73.67	59.79	4.4237	3.6845	5.2780	68.0000			92.00	Option 4: RVP=8, ASTM Slope=3

Cades Cove Maintenance1
NPS

Horizontal Tank
Knoxville, Tennessee

TANKS 4.0
Emissions Report - Summary Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 8)	20.23	258.11	278.34

TANKS 4.0
Emissions Report - Summary Format
Tank Identification and Physical Characteristics

Identification

User Identification:	Cades Cove2
City:	Knoxville
State:	Tennessee
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	Tank #3

Tank Dimensions

Shell Length (ft):	10.75
Diameter (ft):	4.00
Volume (gallons):	1,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	5,647.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Light
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Knoxville, Tennessee (Avg Atmospheric Pressure = 14.25 psia)

TANKS 4.0
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 8)	All	64.53	55.39	73.67	59.79	4.4237	3.6845	5.2780	68.0000			92.00	Option 4: RVP=8, ASTM Slope=3

TANKS 4.0
Emissions Report - Summary Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 8)	40.44	258.11	298.55

TANKS 4.0
Emissions Report - Summary Format
Tank Identification and Physical Characteristics

Identification

User Identification:	Look Rock Maintenance
City:	Knoxville
State:	Tennessee
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	Tank #1

Tank Dimensions

Shell Length (ft):	10.75
Diameter (ft):	4.00
Volume (gallons):	1,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	2,450.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Light
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Knoxville, Tennessee (Avg Atmospheric Pressure = 14.25 psia)

TANKS 4.0
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 8)	All	64.53	55.39	73.67	59.79	4.4237	3.6845	5.2780	68.0000			92.00	Option 4: RVP=8, ASTM Slope=3

TANKS 4.0
Emissions Report - Summary Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 8)	17.55	258.11	275.65

TANKS 4.0
Emissions Report - Summary Format
Tank Identification and Physical Characteristics

Identification

User Identification:	GRSM Oconaluftee
City:	Knoxville
State:	Tennessee
Company:	NPS
Type of Tank:	Horizontal Tank
Description:	AST

Tank Dimensions

Shell Length (ft):	12.00
Diameter (ft):	5.33
Volume (gallons):	2,000.00
Turnovers:	0.00
Net Throughput (gal/yr):	30,613.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Light
Shell Condition:	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig):	0.03

Meteorological Data used in Emissions Calculations: Knoxville, Tennessee (Avg Atmospheric Pressure = 14.25 psia)

TANKS 4.0
Emissions Report - Summary Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 8)	All	64.53	55.39	73.67	59.79	4.4237	3.6845	5.2780	68.0000			92.00	Option 4: RVP=8, ASTM Slope=3

TANKS 4.0
Emissions Report - Summary Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Gasoline (RVP 8)	219.26	462.48	681.74

2000 ACTUAL EMISSIONS FROM CAMPFIRES AT GREAT SMOKY MOUNTAINS NATIONAL PARK

Location	Campsites	Open Days/Yr	Camps	Fires/Yr	Tons/Yr	PM (lbs/yr)	SO_2 (lbs/yr)	NO_x (lbs/yr)	CO (lbs/yr)	VOC (lbs/yr)
Abrams Creek	15	225	3,375	1,688	8	292	3	22	2,131	1,932
Balsam Mountain	46	150	6,900	3,450	17	597	7	45	4,357	3,950
Big Creek	12	225	2,700	1,350	7	234	3	18	1,705	1,546
Cades Cove	161	365	58,765	29,383	147	5,083	59	382	37,110	33,643
Calaloochee	27	225	6,075	3,038	15	525	6	39	3,836	3,478
Cosby	165	225	37,125	18,563	93	3,211	37	241	23,444	21,254
Deep Creek	92	210	19,320	9,660	48	1,671	19	126	12,201	11,061
Elkmont	220	255	56,100	28,050	140	4,853	56	365	35,427	32,117
Look Rock	28	165	4,620	2,310	12	400	5	30	2,918	2,645
Smokemont	142	365	51,830	25,915	130	4,483	52	337	32,731	29,673
	908		246,810	123,405	617	21,349	247	1,604	155,861	141,299
					Tons/Yr	10.67	0.12	0.80	77.93	70.65

Assumption: Fifty percent of camp sites have either an evening or morning campfire

	Emission Factors (lbs/ton)				
	34.6	0.4	2.6	252.6	229

2000 PRESCRIBED FIRE EMISSIONS AT GRAND CANYON NATIONAL PARK

Name		Acres	PM10 (lbs/yr)	PM2.5 (lbs/yr)	CH4 (lbs/yr)	CO (lbs/yr)	PM10 (lbs/acre)	PM2.5 (lbs/acre)	CH4 (lbs/acre)	CO (lbs/acre)
Cades Cove Fields		664	5,976	4,648	1,328	11,952	9	7	2	18
Ski Mtn Pile		4	436	371	212	4,496	121	103	59	1,249
	Totals	668	6,412	5,019	1,540	16,448				
					tons/yr					
			3.21	2.51	0.77	8.22				

TITLE: Results of FOFEM model execution on date: 7/20/2002

FUEL CONSUMPTION CALCULATIONS

Region: Interior_West
Cover Type: SAF/SRM - SRM 613 - Fescue Grassland
Fuel Type: Natural
Fuel Reference: SMFDB 335

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture
Litter	0.00	0.00	0.00	0.0	999	
Wood (0-1/4 inch)	0.00	0.00	0.00	0.0	999	
Wood (1/4-1 inch)	0.00	0.00	0.00	0.0	999	25.0
Wood (1-3 inch)	0.00	0.00	0.00	0.0	999	
Wood (3+ inch) Sound	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Wood (3+ inch) Rotten	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Duff	0.00	0.00	0.00	0.0	2	100.0
Herbaceous	1.56	1.40	0.16	90.0	221	
Shrubs	0.00	0.00	0.00	0.0	23	
Crown foliage	0.00	0.00	0.00	0.0	37	
Crown branchwood	0.00	0.00	0.00	0.0	38	
Total Fuels	1.56	1.40	0.16	90.0		

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Forest Floor Component	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
Duff Depth (in)	0.0	0.0	0.0	0.0	6
Duff Soil Exp (%)	.0	21.9	21.9	21.9	10

	Emissions -- lbs/acre flaming	smoldering	total
PM10	9	0	9
PM2.5	7	0	7
[illegible]	2	0	2
CO	18	0	18
CO2	4994	0	4994

	Consumption tons/acre	Duration hour:min:sec
Flaming:	1.40	00:01:00
Smoldering:	0.00	00:00:00
Total:	1.40	

[TLE: Results of FOFEM model execution on date: 7/20/2002

FUEL CONSUMPTION CALCULATIONS

egion: South_East
over Type: SAF/SRM - SAF 059 - Yellow Poplar - White Oak - Northern Red Oak
uel Type: Natural
uel Reference: FOFEM 231

FUEL CONSUMPTION TABLE

uel omponent ame	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture
itter	2.00	2.00	0.00	100.0	999	
od (0-1/4 inch)	0.05	0.05	0.00	100.0	999	
od (1/4-1 inch)	0.45	0.45	0.00	99.9	999	25.0
od (1-3 inch)	0.00	0.00	0.00	0.0	999	
od (3+ inch) Sound	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
od (3+ inch) Rotten	0.00	0.00	0.00	0.0	999	20.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
iff	4.00	0.25	3.75	6.4	16	100.0
erbaceous	0.05	0.05	0.00	100.0	22	
rubs	0.10	0.00	0.10	0.0	234	
own foliage	0.00	0.00	0.00	0.0	37	
own branchwood	0.00	0.00	0.00	0.0	38	
tal Fuels	6.65	2.80	3.85	42.2		

RE EFFECTS ON FOREST FLOOR COMPONENTS

rest Floor mponent	Preburn Condition	Amount Consumed	Postburn Condition	Percent Reduced	Equation Number
iff Depth (in)	0.8	0.1	0.7	6.4	16
n Soil Exp (%)	.0	0.0	0.0	0.0	14

	Emissions -- lbs/acre flaming	smoldering	total
10	13	108	121
2.5	11	92	103
4	3	56	59
	28	1221	1249
2	7722	4969	12691

	Consumption tons/acre	Duration hour:min:sec
Flaming:	2.17	00:13:00
Smoldering:	2.02	00:13:00
Total:	4.19	

TOTAL GREAT SMOKY MOUNTAINS NP VISITOR VEHICLES

	Gatlinburg	Townsend	Cherokee	Abrams Creek	Big Creek	Cataloochee	Cherokee Orchard	Foothills Parkway E	Cosby	Twentymile	Foothills Parkway W	Greenbrier	Deep Creek	Bryson City Fontana Rd
Jan	53,722	19,606	29,122	1,890	1,448	1,548	1,695	8,936	1,015	77	5,600	3,562	4,132	924
Feb	57,841	23,326	39,541	2,544	1,948	2,082	2,281	12,025	1,366	103	7,536	4,794	5,560	1,243
Mar	77,847	34,243	53,440	2,677	2,050	2,192	2,401	12,656	1,437	109	7,931	5,045	5,851	1,308
Apr	121,567	51,838	76,632	3,964	3,035	3,245	3,555	18,738	2,128	161	11,743	7,470	8,664	1,937
May	124,915	55,451	80,051	4,706	3,604	3,853	4,221	22,248	2,527	191	13,943	8,869	10,286	2,300
Jun	161,039	72,659	105,457	5,764	4,414	4,719	5,169	27,248	3,095	234	17,076	10,862	12,598	2,817
Jul	207,710	92,450	136,148	6,883	5,271	5,635	6,173	32,541	3,696	279	20,393	12,972	15,045	3,364
Aug	153,740	64,782	102,277	7,768	5,949	6,360	6,967	36,724	4,171	315	23,015	14,639	16,980	3,796
Sep	139,927	62,351	94,131	6,031	4,619	4,938	5,409	28,512	3,238	245	17,868	11,366	13,183	2,947
Oct	154,123	90,425	125,846	7,230	5,537	5,919	6,485	34,182	3,882	293	21,422	13,626	15,804	3,534
Nov	93,328	43,619	65,958	3,811	2,919	3,120	3,418	18,017	2,046	155	11,291	7,182	8,330	1,863
Dec	44,697	31,146	39,995	2,304	1,765	1,886	2,067	10,893	1,237	93	6,826	4,342	5,036	1,126
	1,390,456	641,896	948,598	55,573	42,558	45,496	49,842	262,720	29,837	2,254	164,646	104,728	121,471	27,159

Great Smoky Mountains NP Winter Visitor Vehicles

	Gatlinburg	Townsend	Cherokee	Abrams Creek	Big Creek	Cataloochee	Cherokee Orchard	Foothills Parkway E	Cosby	Twentymile	Foothills Parkway W	Greenbrier	Deep Creek	Bryson City Fontana Rd
Jan	53,722	19,606	29,122	1,890	1,448	1,548	1,695	8,936	1,015	77	5,600	3,562	4,132	924
Feb	57,841	23,326	39,541	2,544	1,948	2,082	2,281	12,025	1,366	103	7,536	4,794	5,560	1,243
Dec	44,697	31,146	39,995	2,304	1,765	1,886	2,067	10,893	1,237	93	6,826	4,342	5,036	1,126
	156,260	74,078	108,658	6,738	5,160	5,516	6,043	31,855	3,618	273	19,963	12,698	14,728	3,293

Great Smoky Mountains NP Summer Visitor Vehicles

	Gatlinburg	Townsend	Cherokee	Abrams Creek	Big Creek	Cataloochee	Cherokee Orchard	Foothills Parkway E	Cosby	Twentymile	Foothills Parkway W	Greenbrier	Deep Creek	Bryson City Fontana Rd
Mar	77,847	34,243	53,440	2,677	2,050	2,192	2,401	12,656	1,437	109	7,931	5,045	5,851	1,308
Apr	121,567	51,838	76,632	3,964	3,035	3,245	3,555	18,738	2,128	161	11,743	7,470	8,664	1,937
May	124,915	55,451	80,051	4,706	3,604	3,853	4,221	22,248	2,527	191	13,943	8,869	10,286	2,300
Jun	161,039	72,659	105,457	5,764	4,414	4,719	5,169	27,248	3,095	234	17,076	10,862	12,598	2,817
Jul	207,710	92,450	136,148	6,883	5,271	5,635	6,173	32,541	3,696	279	20,393	12,972	15,045	3,364
Aug	153,740	64,782	102,277	7,768	5,949	6,360	6,967	36,724	4,171	315	23,015	14,639	16,980	3,796
Sep	139,927	62,351	94,131	6,031	4,619	4,938	5,409	28,512	3,238	245	17,868	11,366	13,183	2,947
Oct	154,123	90,425	125,846	7,230	5,537	5,919	6,485	34,182	3,882	293	21,422	13,626	15,804	3,534
Nov	93,328	43,619	65,958	3,811	2,919	3,120	3,418	18,017	2,046	155	11,291	7,182	8,330	1,863
	1,234,196	567,818	839,940	48,835	37,398	39,980	43,799	230,866	26,220	1,981	144,683	92,030	106,743	23,866

GREAT SMOKY MOUNTAINS NP SUMMER VISITOR VMT

Entrance	Exit	Vehicles	Percent	Vehicles	Length	Annual VMT
Gatlinburg	Gatlinburg via Cades Cove	1,234,196	50	617,098	65	40,111,370
	Cherokee	1,234,196	50	617,098	34	20,981,332
Townsend	Townsend via Cades Cove	567,818	50	283,909	30	8,517,270
	Cherokee	567,818	50	283,909	52	14,763,268
Cherokee	Cherokee via Cades Cove	839,940	50	419,970	125	52,496,250
	Gatlinburg	839,940	50	419,970	34	14,278,980
Abrams Creek	Abrams Creek	48,835	100	48,835	2	97,670
Big Creek	Big Creek	37,398	100	37,398	2	74,796
Cataloochee	Cataloochee	39,980	100	39,980	10	399,799
Cherokee Orchard	Cherokee Orchard	43,799	100	43,799	2	87,597
Foothills Parkway East	Foothills Parkway East	230,866	100	230,866	15	3,462,988
Cosby	Cosby	26,220	100	26,220	5	131,098
Twentymile	Twentymile	1,981	100	1,981	1	1,981
Foothills Parkway West	Foothills Parkway West	144,683	100	144,683	5	723,415
Greenbrier	Greenbrier	92,030	100	92,030	6	552,181
Deep Creek	Deep Creek	106,743	100	106,743	2	213,485
Bryson City	Bryson City	23,866	100	23,866	2	47,732
						156,941,211

GREAT SMOKY MOUNTAINS NP WINTER VISITOR VMT

Entrance	Exit	Vehicles	Percent	Vehicles	Length	Annual VMT
Gatlinburg	Gatlinburg via Cades Cove	156,260	50	78,130	65	5,078,450
	Cherokee	156,260	50	78,130	34	2,656,420
Townsend	Townsend via Cades Cove	74,078	50	37,039	30	1,111,170
	Cherokee	74,078	50	37,039	52	1,926,028
Cherokee	Cherokee via Cades Cove	108,658	50	54,329	125	6,791,125
	Gatlinburg	108,658	50	54,329	34	1,847,186
Abrams Creek	Abrams Creek	6,738	100	6,738	2	13,476
Big Creek	Big Creek	5,160	100	5,160	2	10,320
Cataloochee	Cataloochee	5,516	100	5,516	10	55,164
Cherokee Orchard	Cherokee Orchard	6,043	100	6,043	2	12,087
Foothills Parkway East	Foothills Parkway East	31,855	100	31,855	15	477,818
Cosby	Cosby	3,618	100	3,618	5	18,089
Twentymile	Twentymile	273	100	273	1	273
Foothills Parkway West	Foothills Parkway West	19,963	100	19,963	5	99,816
Greenbrier	Greenbrier	12,698	100	12,698	6	76,189
Deep Creek	Deep Creek	14,728	100	14,728	2	29,456
Bryson City	Bryson City	47,663	100	47,663	2	95,326
						20,298,393

GREAT SMOKY MOUNTAINS NP VISITOR VEHICLE EMISSIONS

Summer VMT	Winter VMT
156,941,211	20,298,393

	Emission Factors (g/mi)				Emissions (tons/yr)			
	NOx	CO	VOC	PM10	NOx	CO	VOC	PM10
Summer	0.93	8.41	0.95	0.91	160.55	1,451.86	164.00	157.10
Winter	1.06	12.65	0.99	0.91	23.67	282.45	22.10	20.32
Total					184.22	1,734.32	186.11	177.42
					Emissions (lbs/yr)			
					368,438	3,468,631	372,217	354,834

GREAT SMOKY MOUNTAINS NP-OWNED VEHICLE EMISSIONS

	LDGV	LDGT	LDGT2	LDDT	HDGV
Vehicles	29	157	8	25	15
VMT	145,000	471,000	24,000	75,000	32,600

	Emission Factors (g/mi)				Emissions (tons/yr)			
	NOx	CO	VOC	PM10	NOx	CO	VOC	PM10
LDGV	0.73	7.65	0.83	0.91	233	2,440	265	290
LDGT	0.93	10.52	1.00	0.91	964	10,901	1,036	943
LDGT2	1.00	10.52	0.97	0.91	53	555	51	48
LDDT	1.13	0.88	0.44	0.91	186	145	73	150
HDGV	4.21	8.46	1.21	0.91	302	607	87	65
				Total	1,738	14,649	1,512	1,497
				tons/yr	0.87	7.32	0.76	0.75

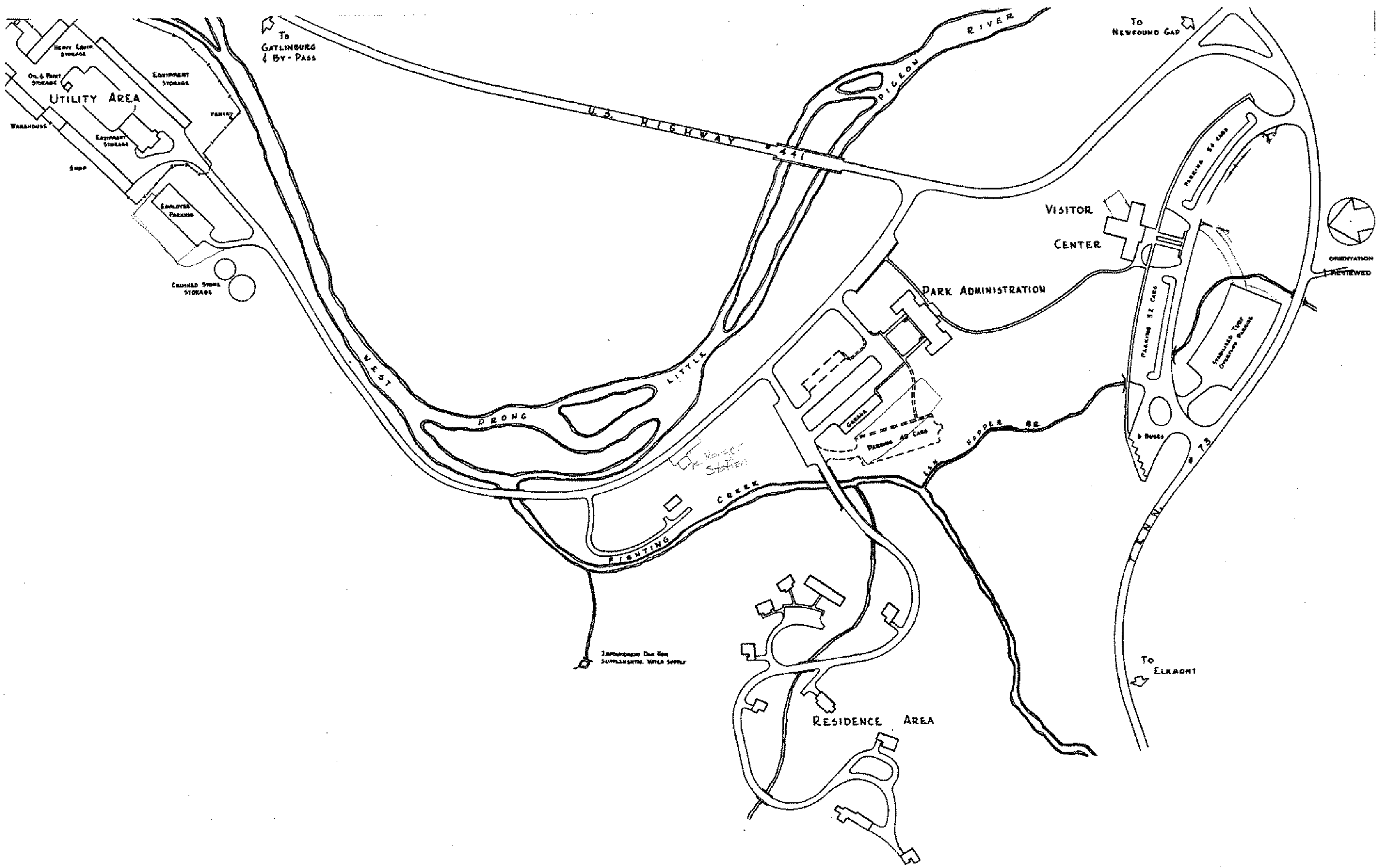
2000 GREAT SMOKY MOUNTAINS NP NONROAD VEHICLE EMISSIONS

		Emission Factors (gm/hp-hr)							Emissions (lbs/yr)			
Vehicle	No.	PM	Nox	CO	VOC	hp	load	hrs/yr	PM	Nox	CO	VOC
Utility Vehicle	11	2.04	1.03	2.31	2.19	15	0.55	1100	40.7	20.6	46.1	43.7
Tractors	13	2.04	1.03	2.31	2.19	42.35	0.68	1300	168.0	84.8	190.3	180.4
										0.0	0.0	
Backhoe	9	2.04	1.03	2.31	2.19	77	0.55	900	171.1	86.4	193.7	183.6
Riding Mower	7	1.11	10.3	4.8	1.3	15	0.55	700	14.1	130.9	61.0	16.5
Bobcat	1	2.04	1.03	2.31	2.19	15	0.55	100	3.7	1.9	4.2	4.0
Dozer	1	2.04	1.03	2.31	2.19	77	0.55	100	19.0	9.6	21.5	20.4
Grader	4	1.06	9.6	3.8	1.43	172	0.61	400	97.9	886.4	350.9	132.0
Sweeper	4	1.7	14	6.06	1.46	30	0.68	400	30.5	251.3	108.8	26.2
Forklift	3	1.06	9.6	3.8	1.43	172	0.61	300	73.4	664.8	263.1	99.0
Front End Loader	0	1.11	10.3	4.8	1.3	77	0.55	0	0.00	0.00	0.00	0.00
Roller/Compactor	1	2.04	1.03	2.31	2.19	30	0.55	100	7.4	3.7	8.4	7.9
Chipper	3	3.99	0.9	1372	495	30	0.55	0	0.0	0.0	0.0	0.0
							Totals:	(lbs/yr)	626	2,140	1,248	714
								(tons/yr)	0.31	1.07	0.62	0.36

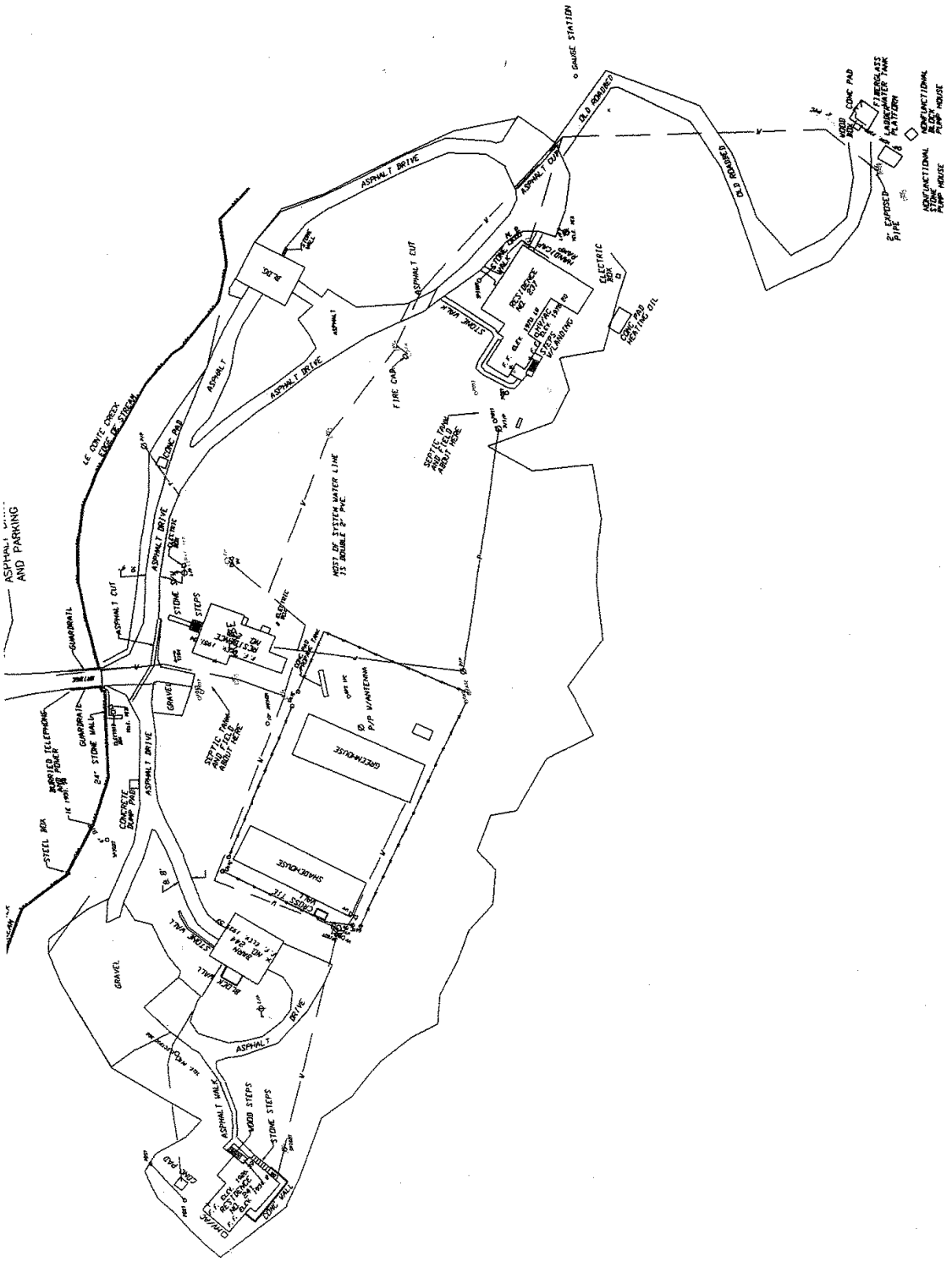
9/24/02

APPENDIX B

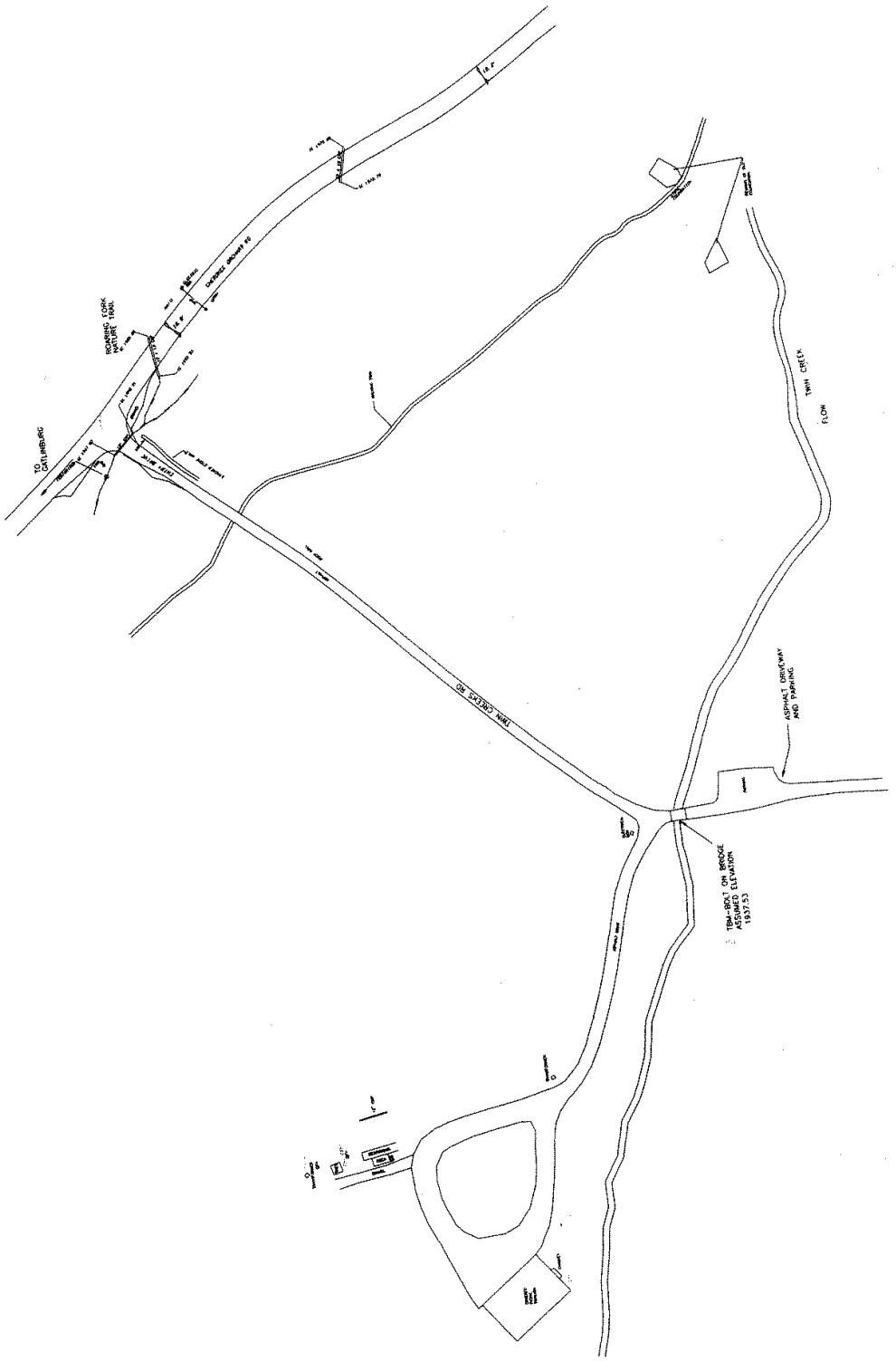
DEVELOPED AREAS IN GREAT SMOKY MOUNTAINS NATIONAL PARK



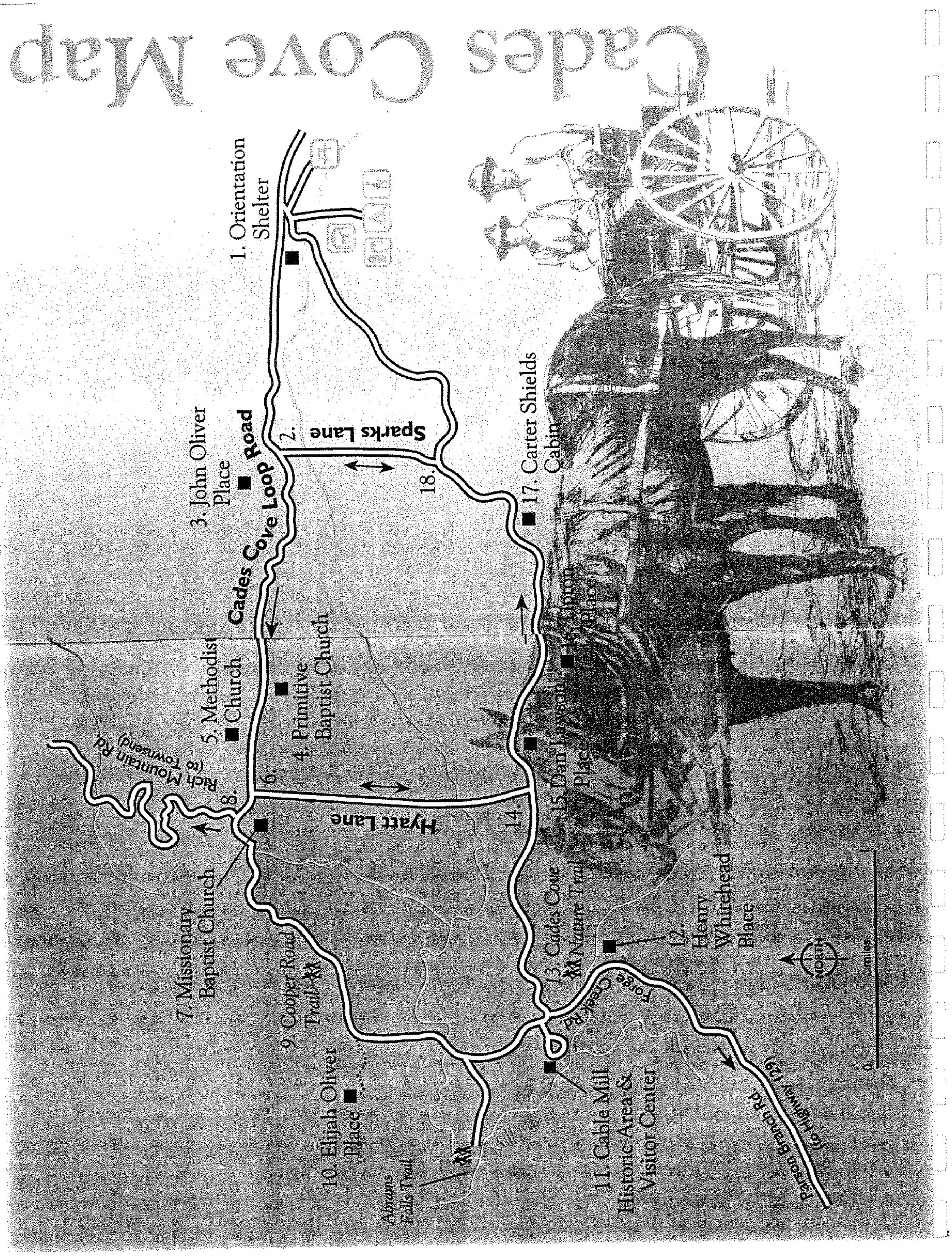
Sugarlands Visitor Center, Park Headquarters, Residential Area, and Utility Area

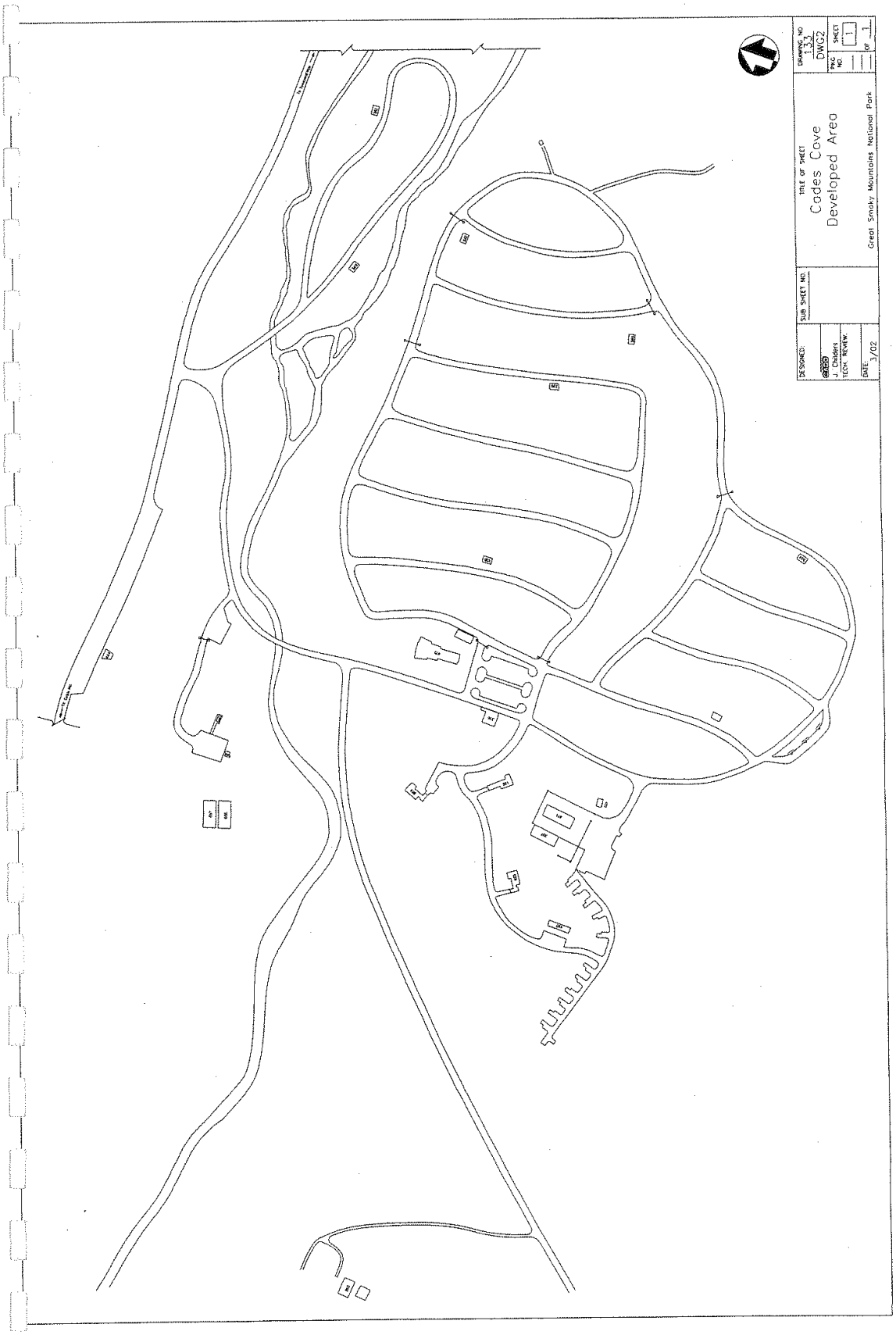


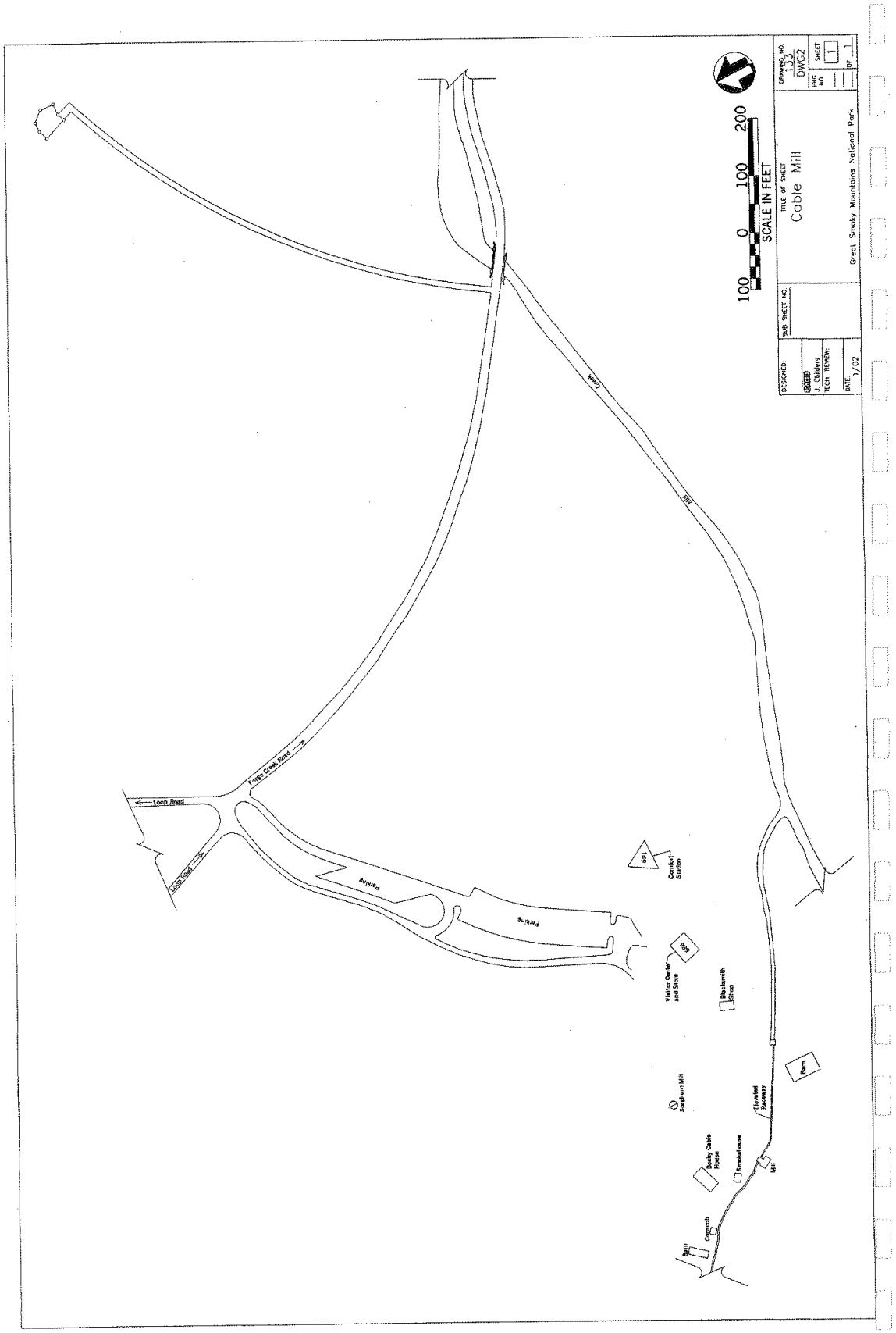
TWIN CREEKS ADMINISTRATION AREA

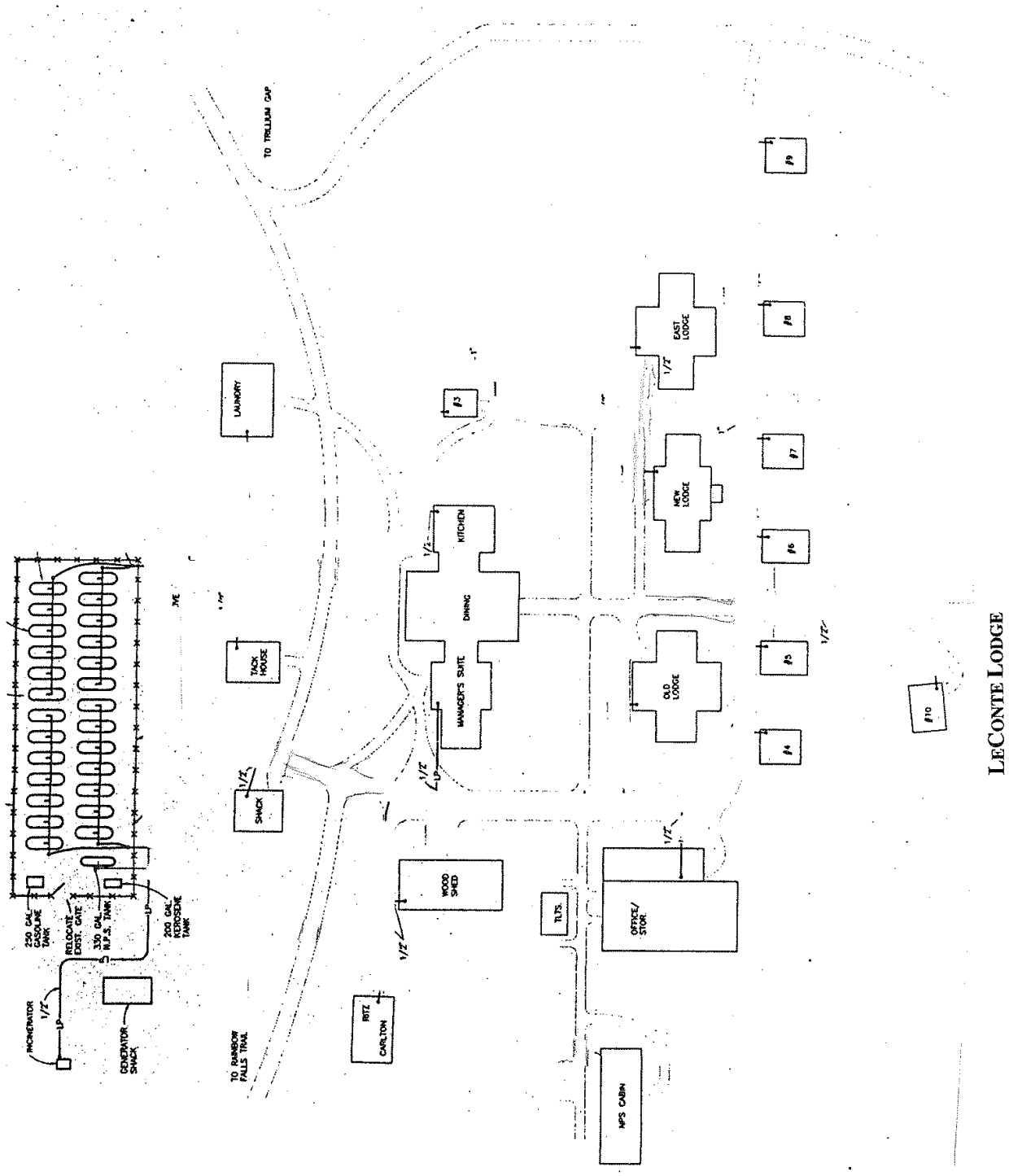


TWIN CREEKS PICNIC AREA

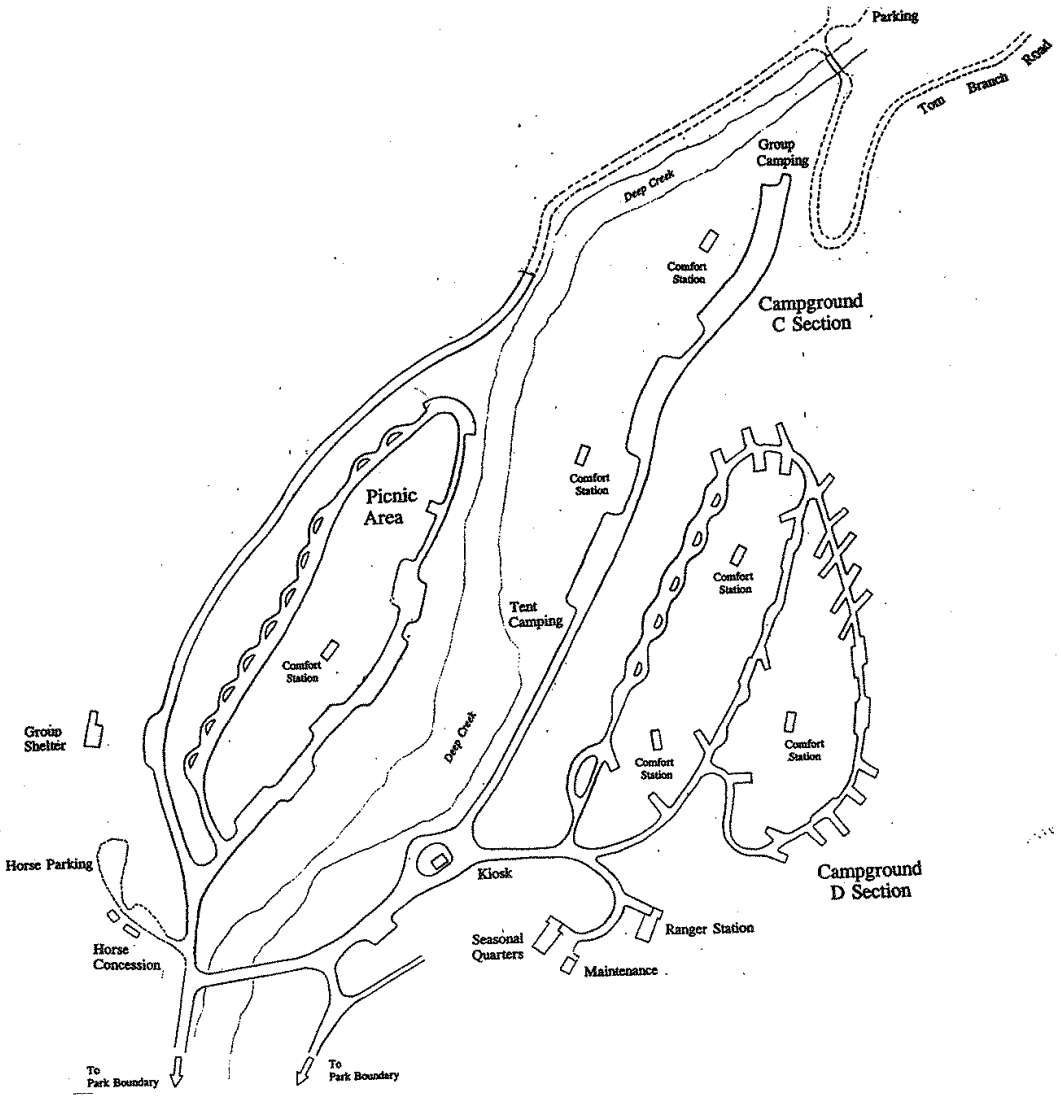

Cades Cove Map
1. Orientation Shelter
2.
3. John Oliver Place
Cades Cove Loop Road
Sparks Lane
18.
17. Carter Shields Cabin
16. Tipton Place
5. Methodist Church
4. Primitive Baptist Church
15. Dan Lawson Place
Rich Mountain Rd (to Townsend)
6.
8.
Hyatt Lane
14.
7. Missionary Baptist Church
13. Cades Cove Nature Trail
12. Henry Whitehead Place
9. Cooper Road Trail
Forge Creek Rd
NORTH
0
miles
1
10. Elijah Oliver Place
11. Cable Mill Historic Area & Visitor Center
Abrams Falls Trail
Parson Branch Rd. (to Highway 129)


DRAWING NO
133
DWG2
SHEET
1
OF
1
TITLE OF SHEET
Cades Cove
Developed Area
Great Smoky Mountains National Park
DESIGNED:
J. Childers
TECH. REVIEW:
DATE:
3/02
SUB SHEET NO.

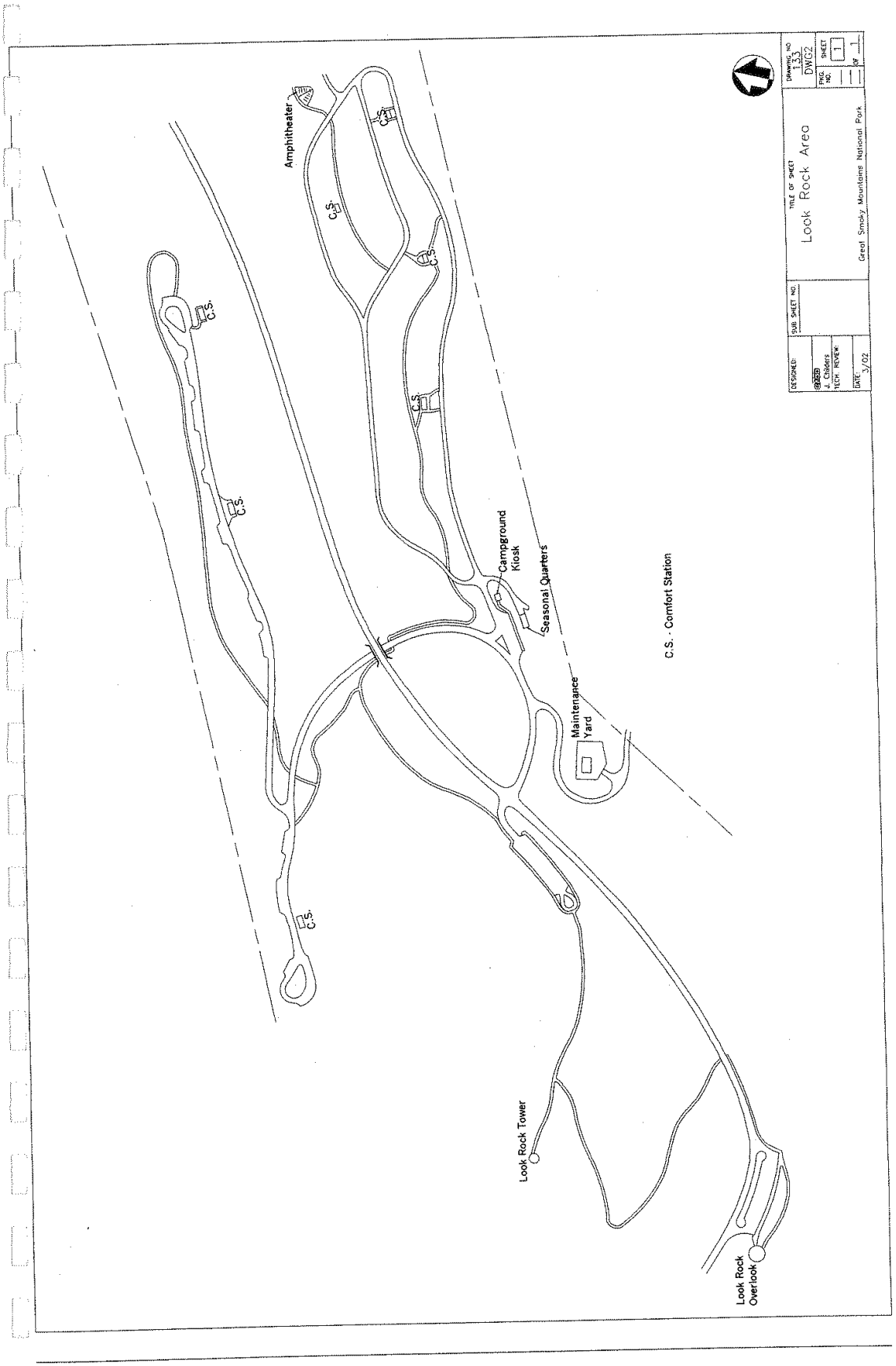

Cable Mill
Great Smoky Mountains National Park
SCALE IN FEET
100 0 100 200
Loop Road
Forge Creek Road
Parking
Comfort Station
Visitor Center and Store
Blacksmith Shop
Barn
Elevated Raceway
Becky Cable House
Smokehouse
Mill
Corncrib
Barn
Sorghum Mill

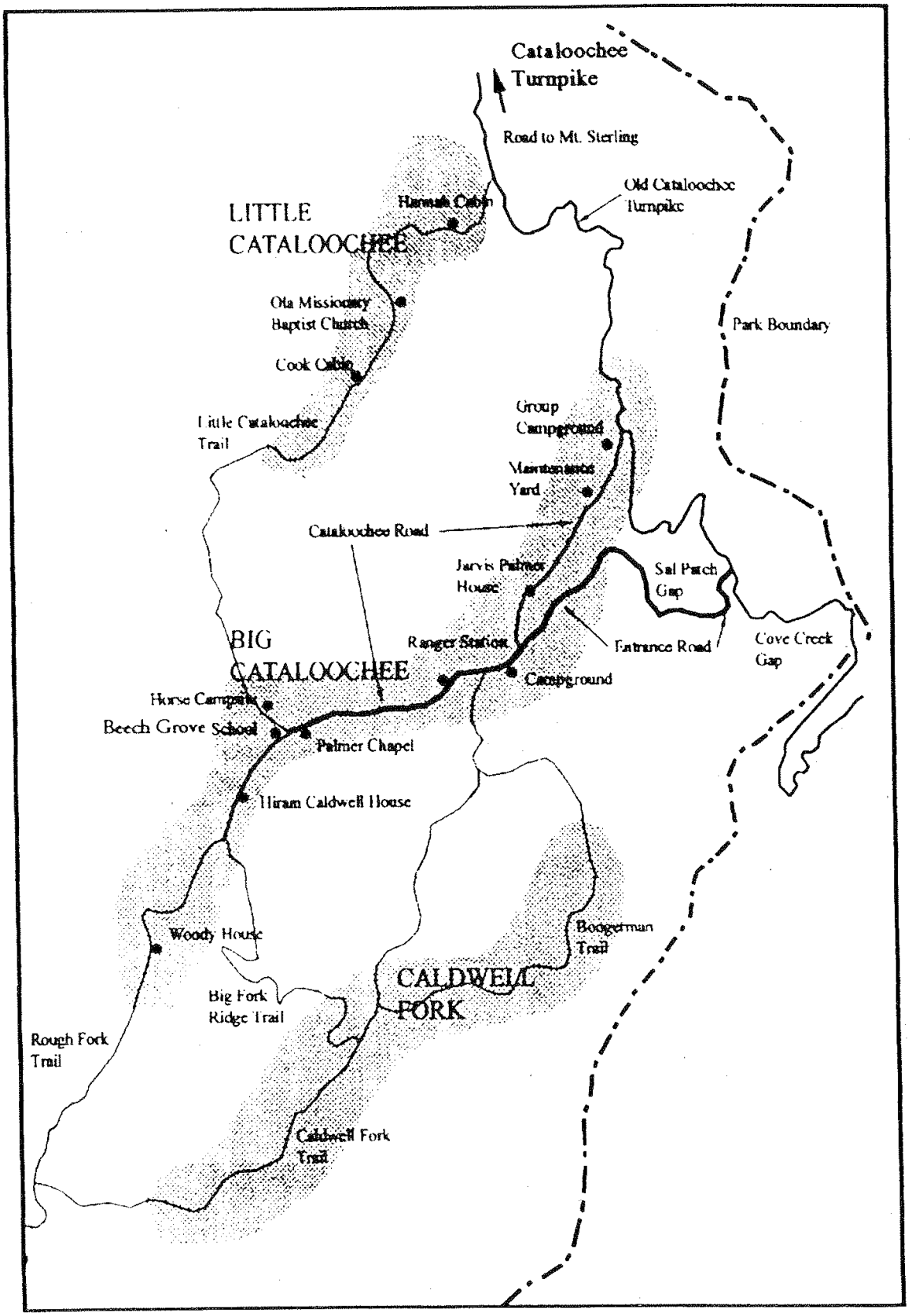


LECONTE LODGE

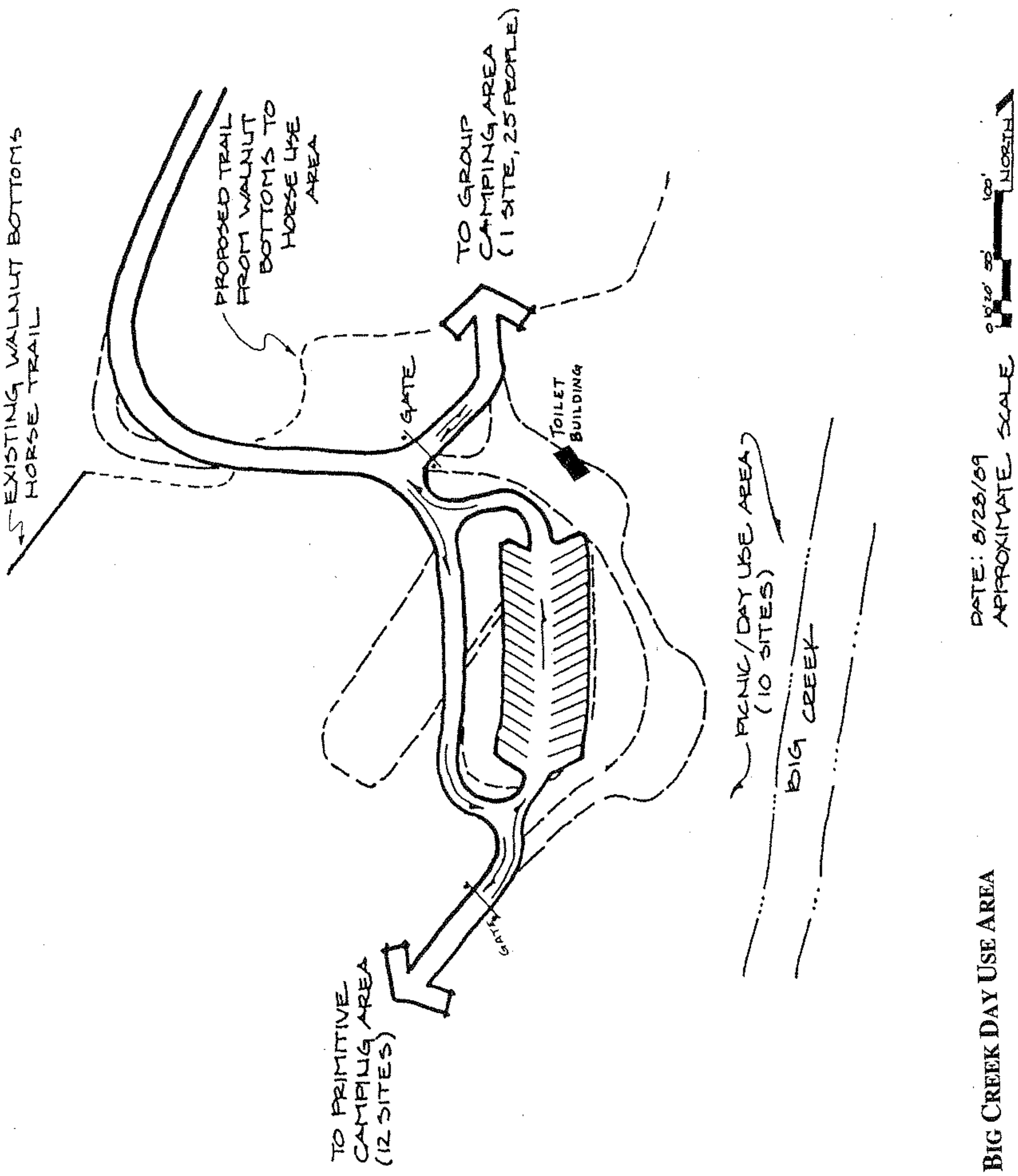

Parking
Tom Branch Road
Group Camping
Deep Creek
Comfort Station
Campground C Section
Comfort Station
Picnic Area
Comfort Station
Tent Camping
Comfort Station
Group Shelter
Comfort Station
Deep Creek
Comfort Station
Horse Parking
Kiosk
Campground D Section
Seasonal Quarters
Ranger Station
Horse Concession
Maintenance
To Park Boundary
To Park Boundary

DEEP CREEK

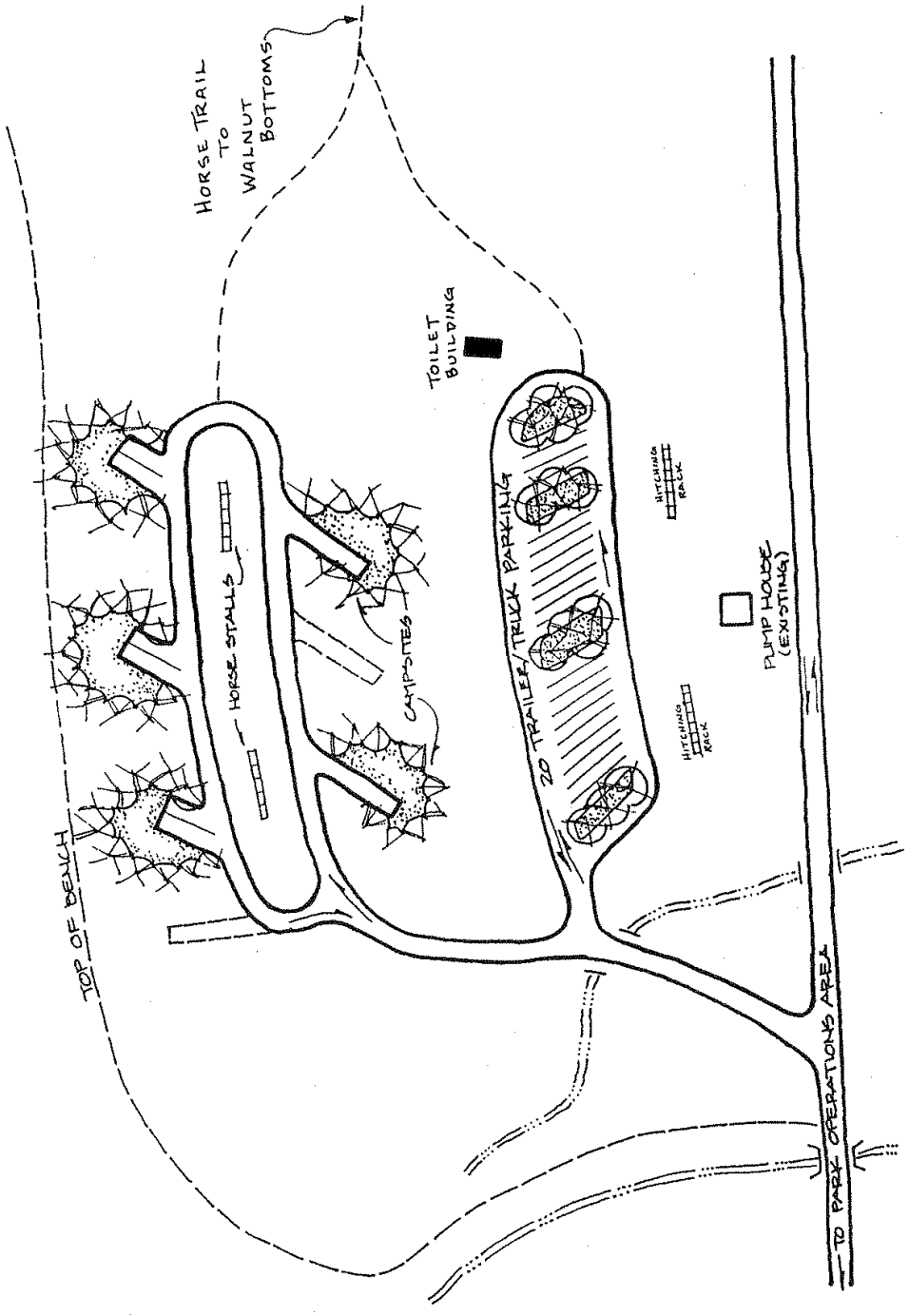

Amphitheater
C.S.
Campground Kiosk
Seasonal Quarters
Maintenance Yard
Look Rock Tower
Look Rock Overlook
C.S. - Comfort Station
DESIGNED:
DRAWN: J. Childers
TECH. REVIEW:
DATE: 3/02
SUB SHEET NO.
TITLE OF SHEET
Look Rock Area
Great Smoky Mountains National Park
DRAWING NO.
133
DWG2
PKG NO.
SHEET
1
OF 1



Cataloochee Map

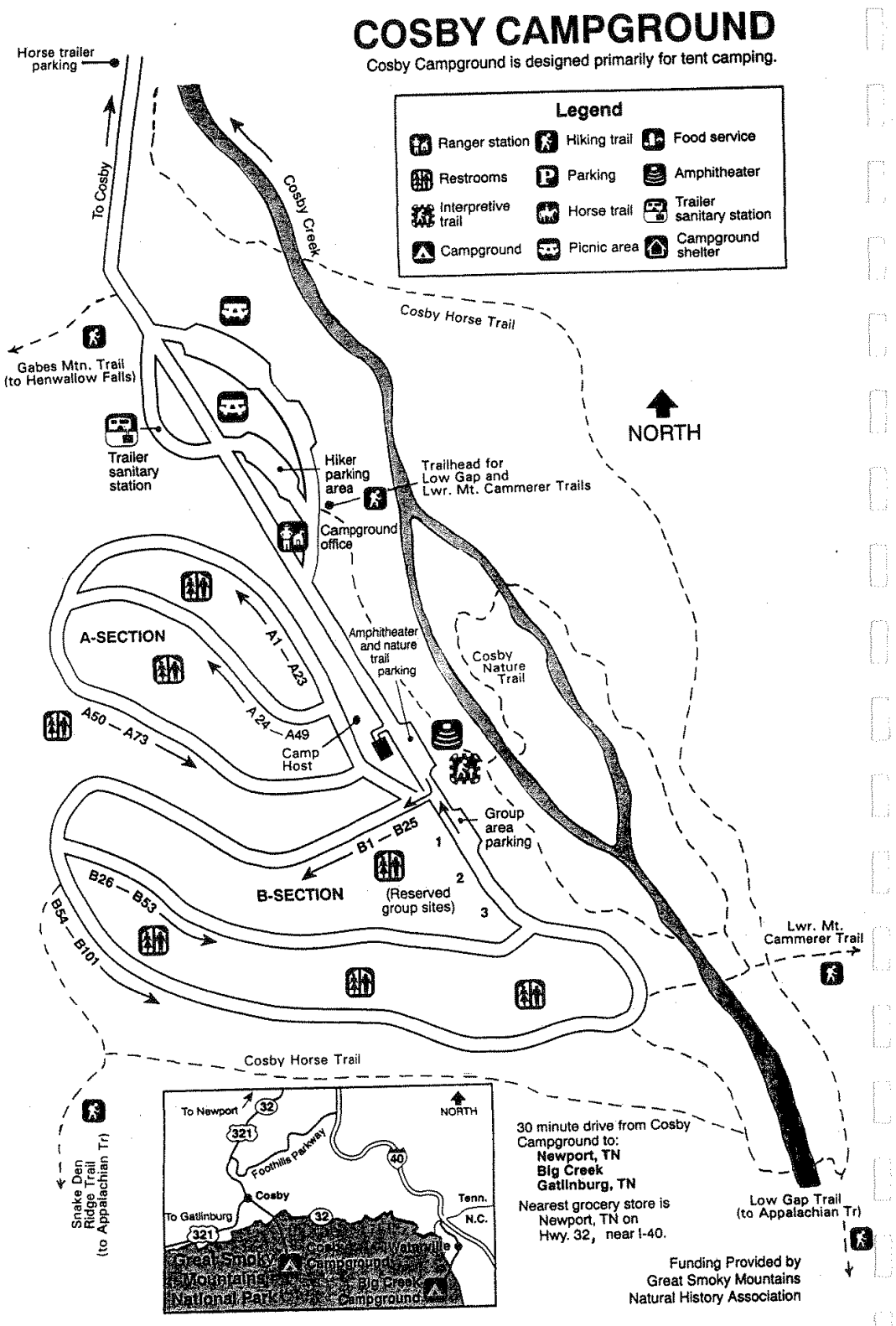


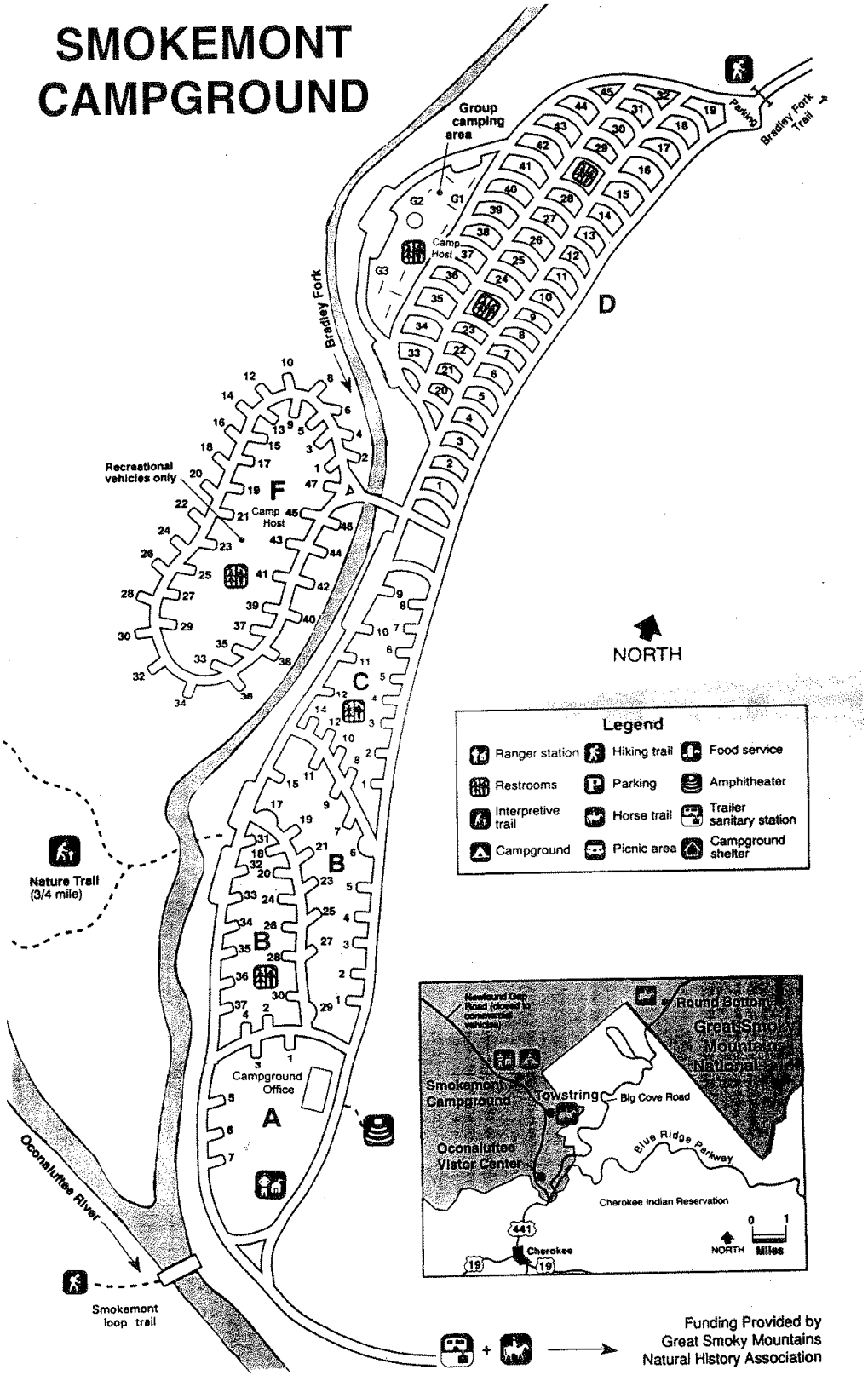
BIG CREEK DAY USE AREA



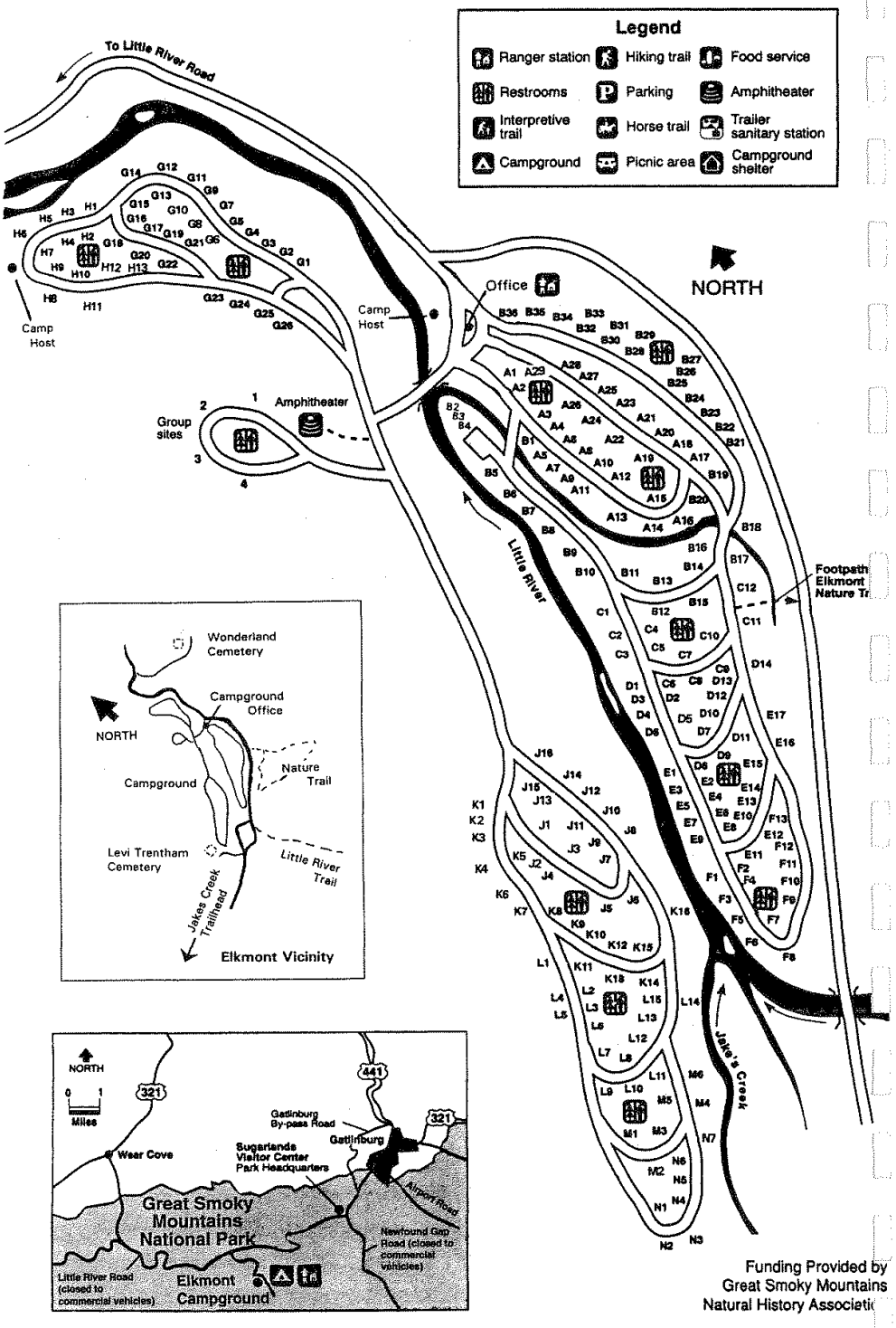
BIG CREEK HORSE USE AREA

OCONALUFTEE VISITOR CENTER, MAINTENANCE YARD, AND RESIDENTIAL AREA

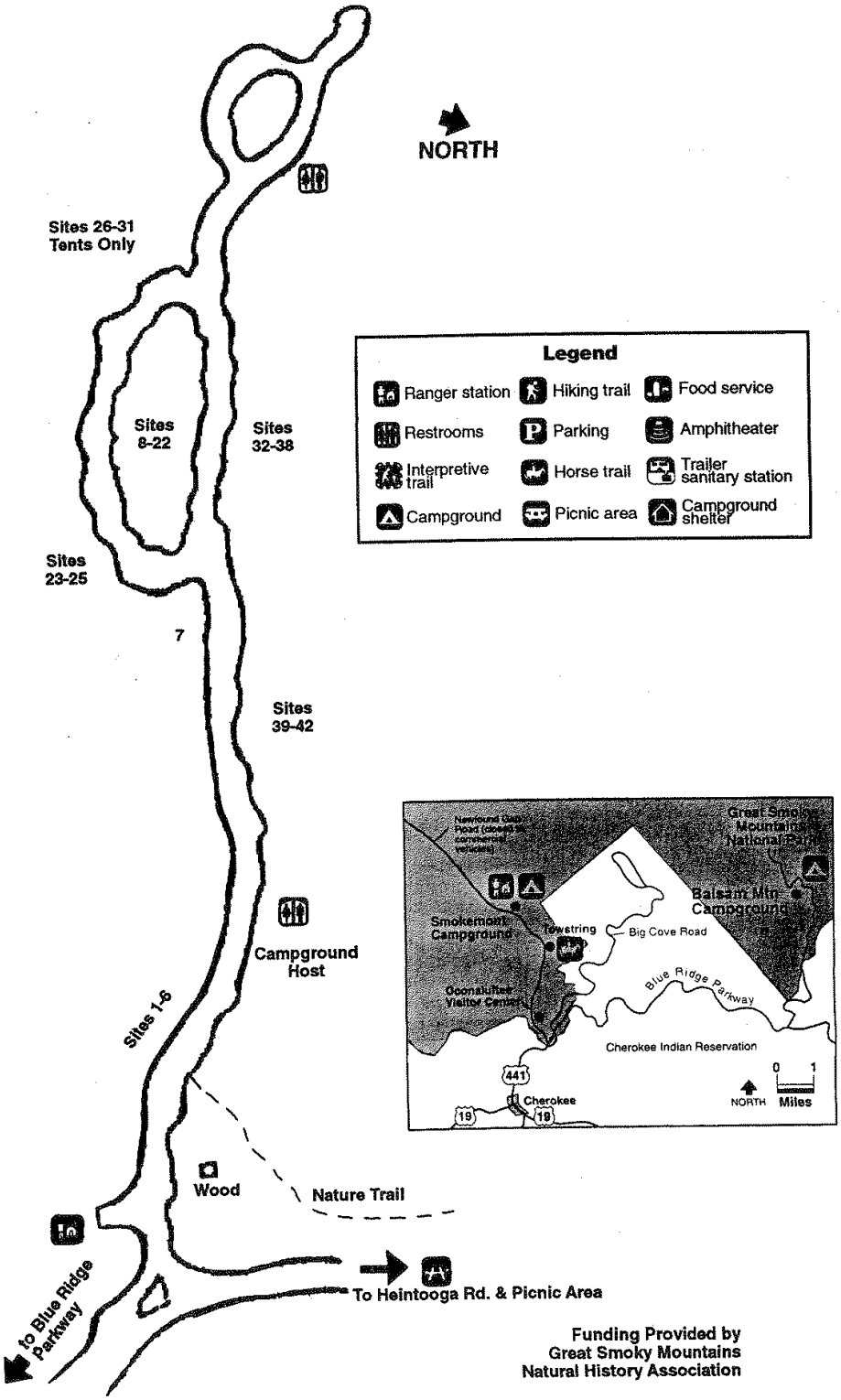

COSBY CAMPGROUND
Cosby Campground is designed primarily for tent camping.
Legend
Ranger station
Hiking trail
Food service
Restrooms
Parking
Amphitheater
Interpretive trail
Horse trail
Trailer sanitary station
Campground
Picnic area
Campground shelter
Horse trailer parking
To Cosby
Cosby Creek
Cosby Horse Trail
Gabes Mtn. Trail (to Henwallow Falls)
NORTH
Trailer sanitary station
Hiker parking area
Trailhead for Low Gap and Lwr. Mt. Cammerer Trails
Campground office
A-SECTION
A1 — A23
A24 — A49
A50 — A73
Camp Host
Amphitheater and nature trail parking
Cosby Nature Trail
Group area parking
B1 — B25
B-SECTION
(Reserved group sites)
1
2
3
B26 — B53
B54 — B101
Lwr. Mt. Cammerer Trail
Cosby Horse Trail
Snake Den Ridge Trail (to Appalachian Tr)
To Newport
32
321
NORTH
Foothills Parkway
40
Cosby
To Gatlinburg
Tenn.
N.C.
Great Smoky Mountains National Park
Campground
Big Creek Campground
30 minute drive from Cosby Campground to:
Newport, TN
Big Creek
Gatlinburg, TN
Nearest grocery store is Newport, TN on Hwy. 32, near I-40.
Low Gap Trail (to Appalachian Tr)
Funding Provided by Great Smoky Mountains Natural History Association

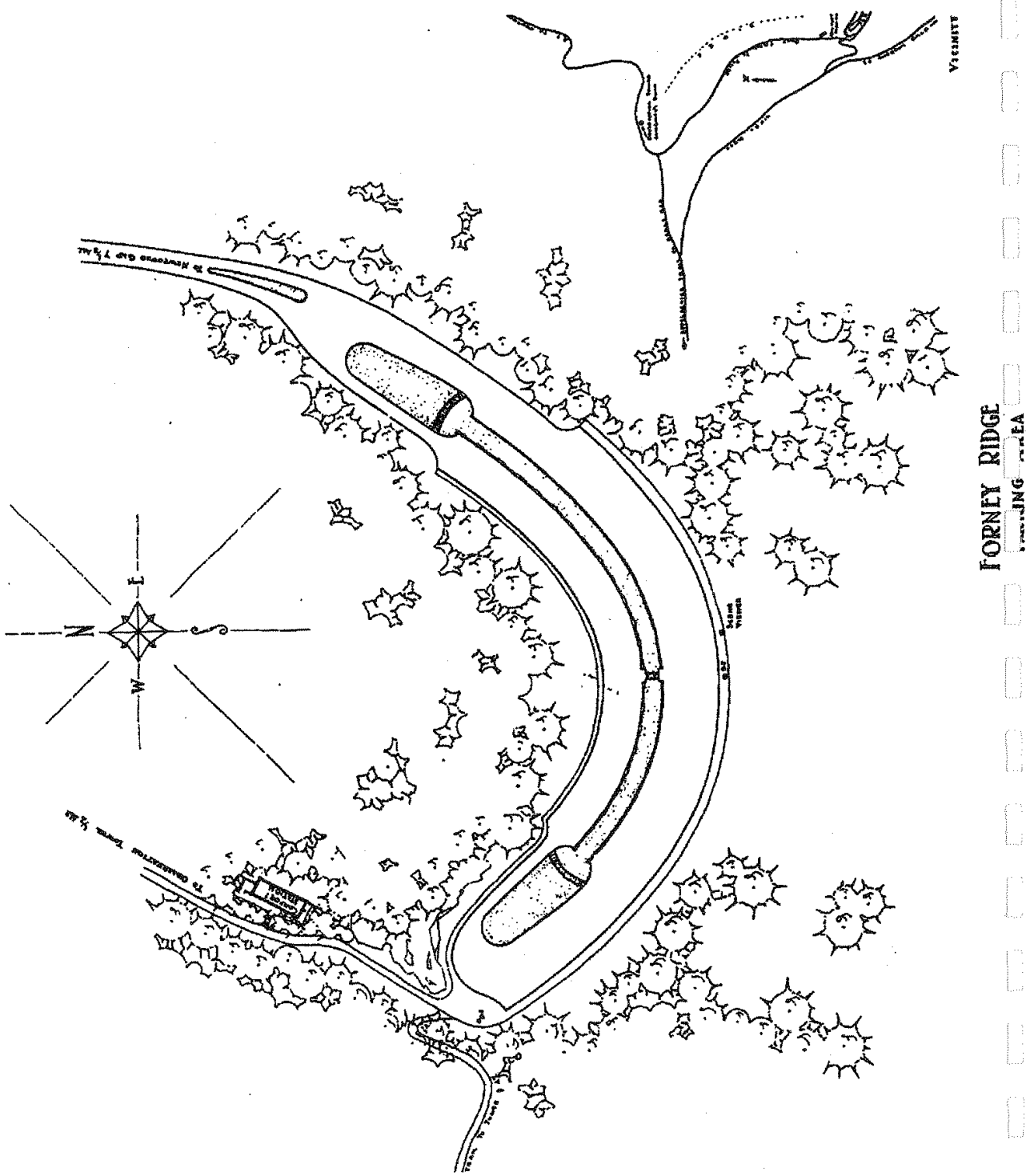

SMOKEMONT CAMPGROUND
Group camping area
Parking
Bradley Fork Trail
Bradley Fork
Camp Host
Recreational vehicles only
Camp Host
D
F
C
B
B
A
NORTH
Legend
Ranger station
Hiking trail
Food service
Restrooms
Parking
Amphitheater
Interpretive trail
Horse trail
Trailer sanitary station
Campground
Picnic area
Campground shelter
Nature Trail (3/4 mile)
Campground Office
Oconaluftee River
Smokemont loop trail
Round Bottom
Great Smoky Mountains National Park
Smokemont Campground
Towstring
Big Cove Road
Oconaluftee Visitor Center
Blue Ridge Parkway
Cherokee Indian Reservation
441
Cherokee
19
NORTH
0
1
Miles
Funding Provided by
Great Smoky Mountains
Natural History Association

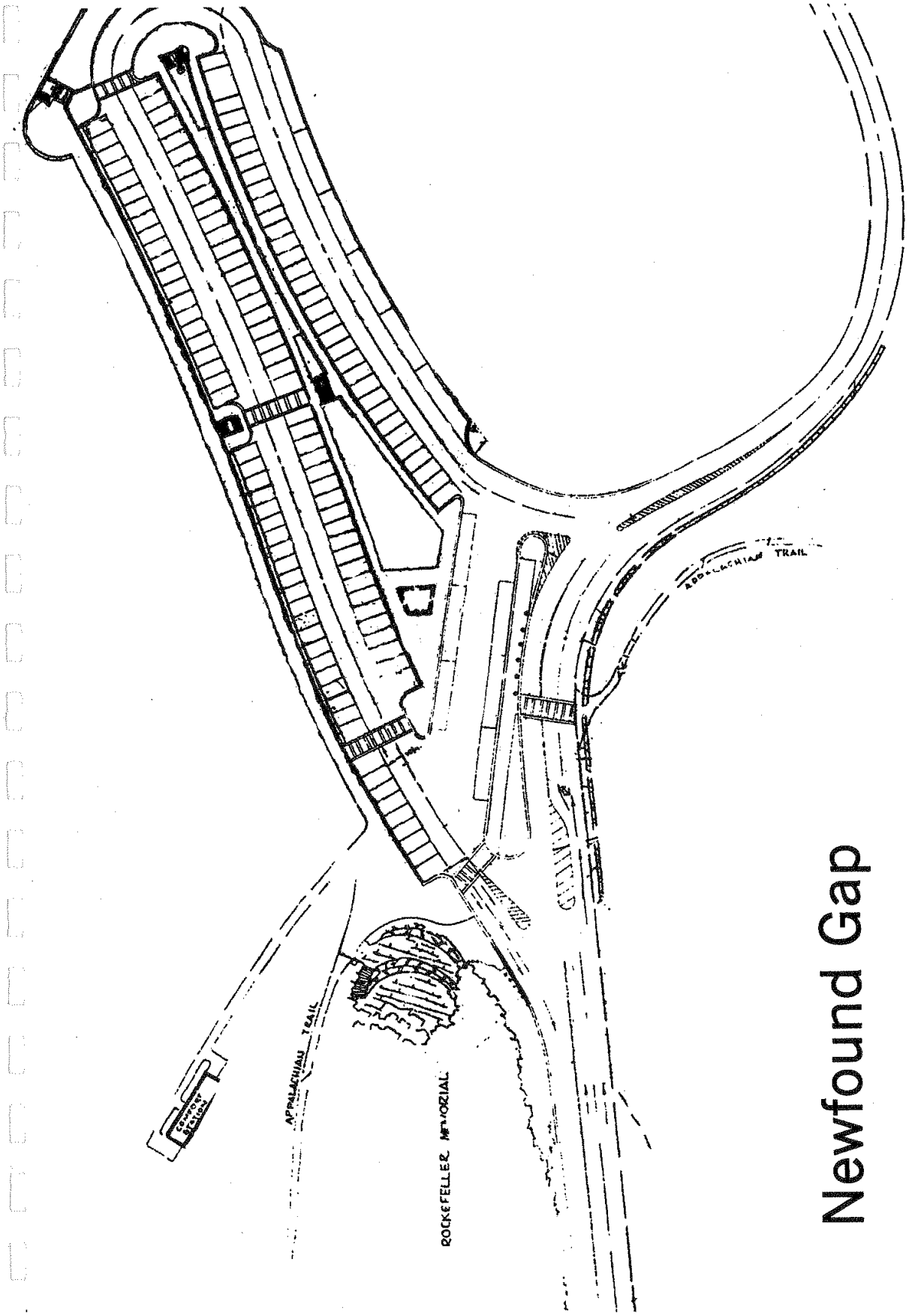
ELKMONT CAMPGROUND



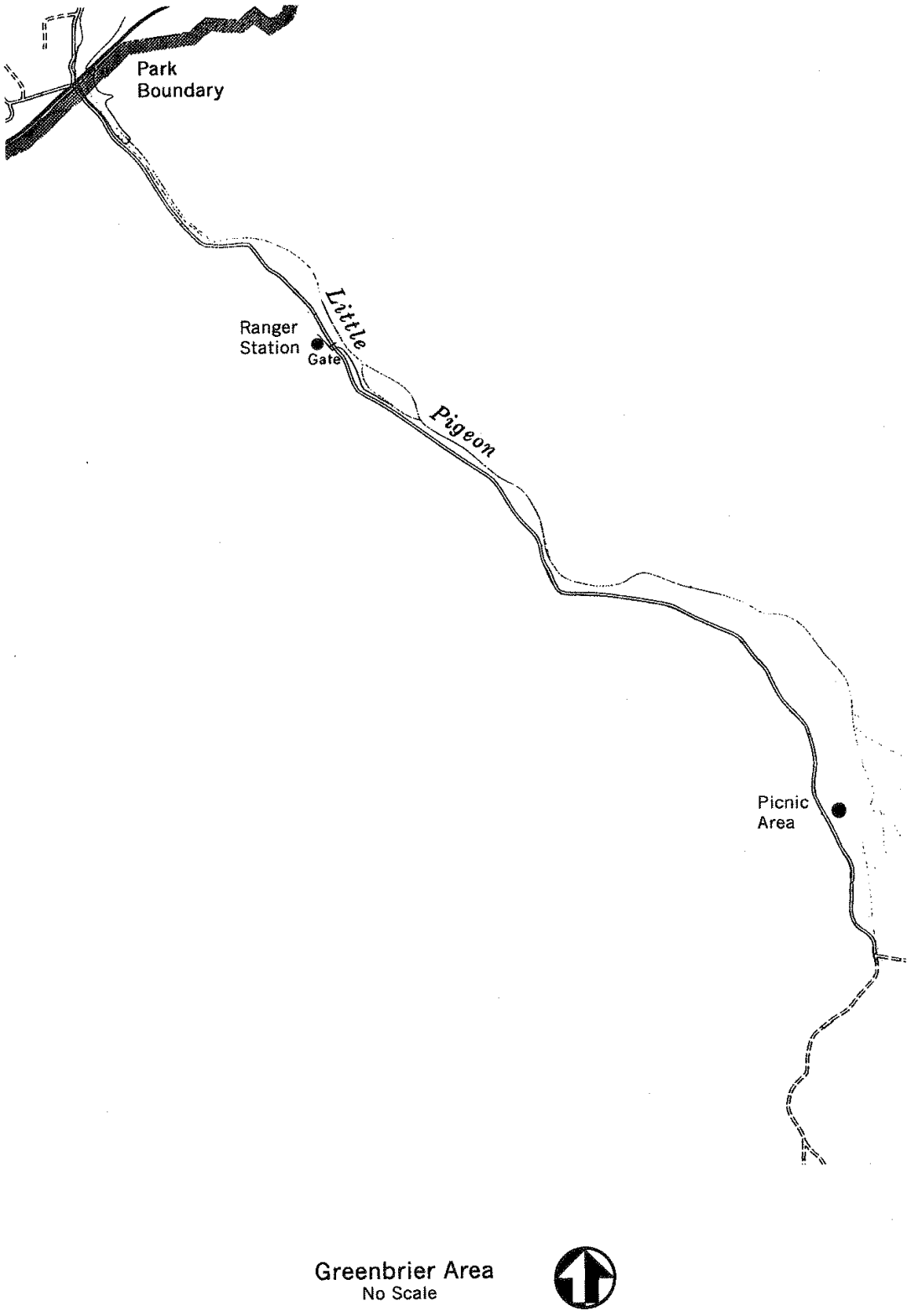
BALSAM MOUNTAIN CAMPGROUND

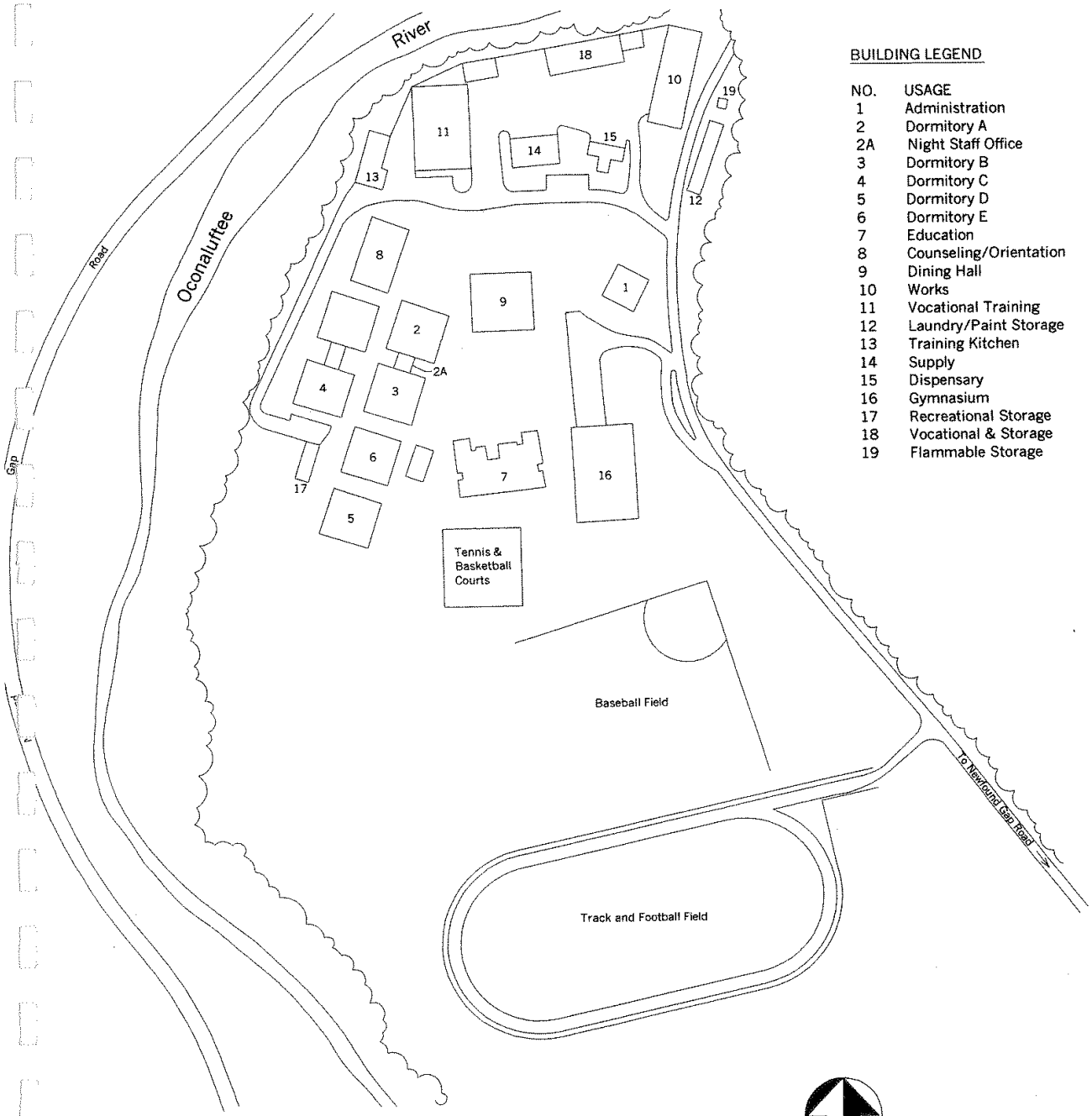



FORNEY RIDGE

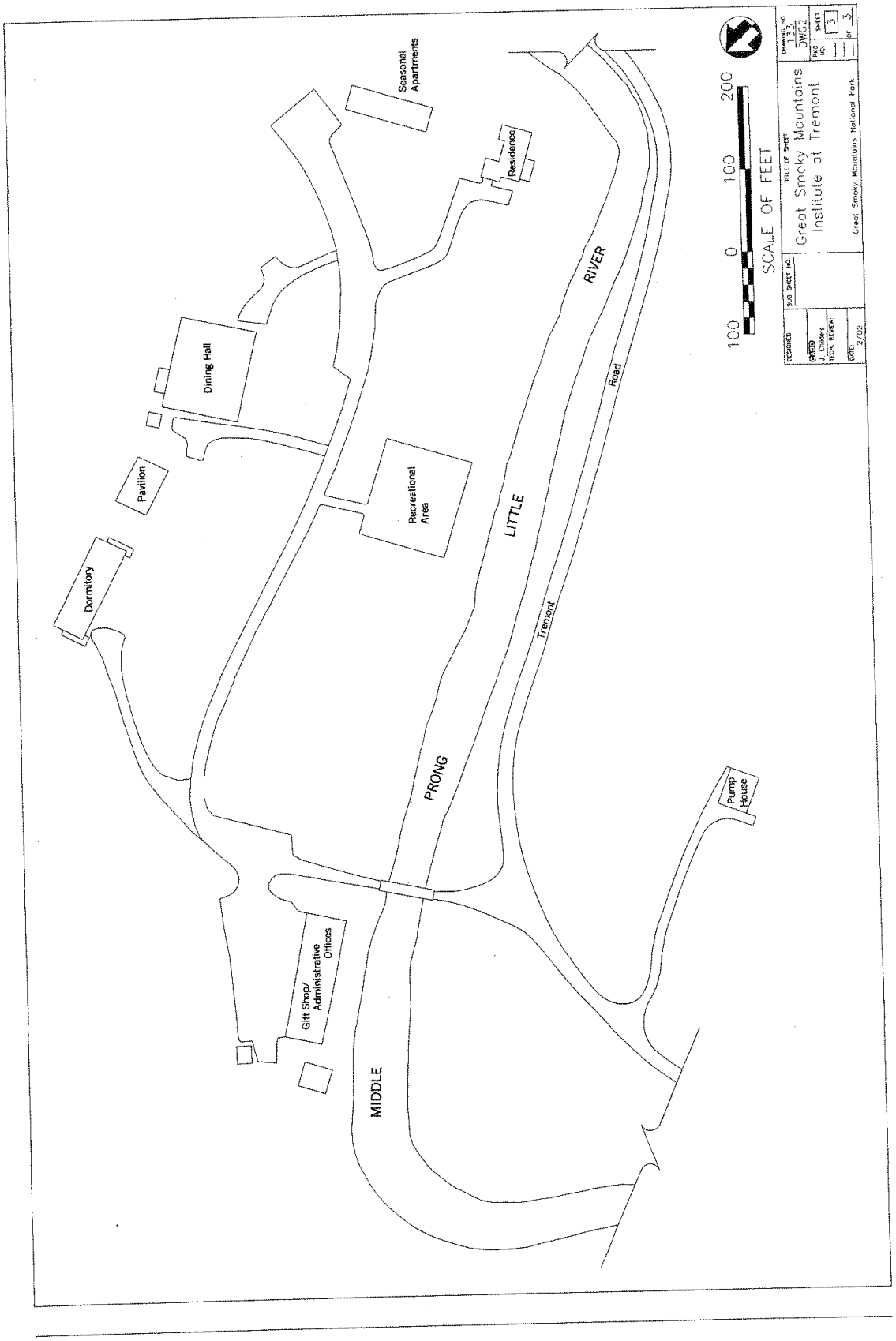


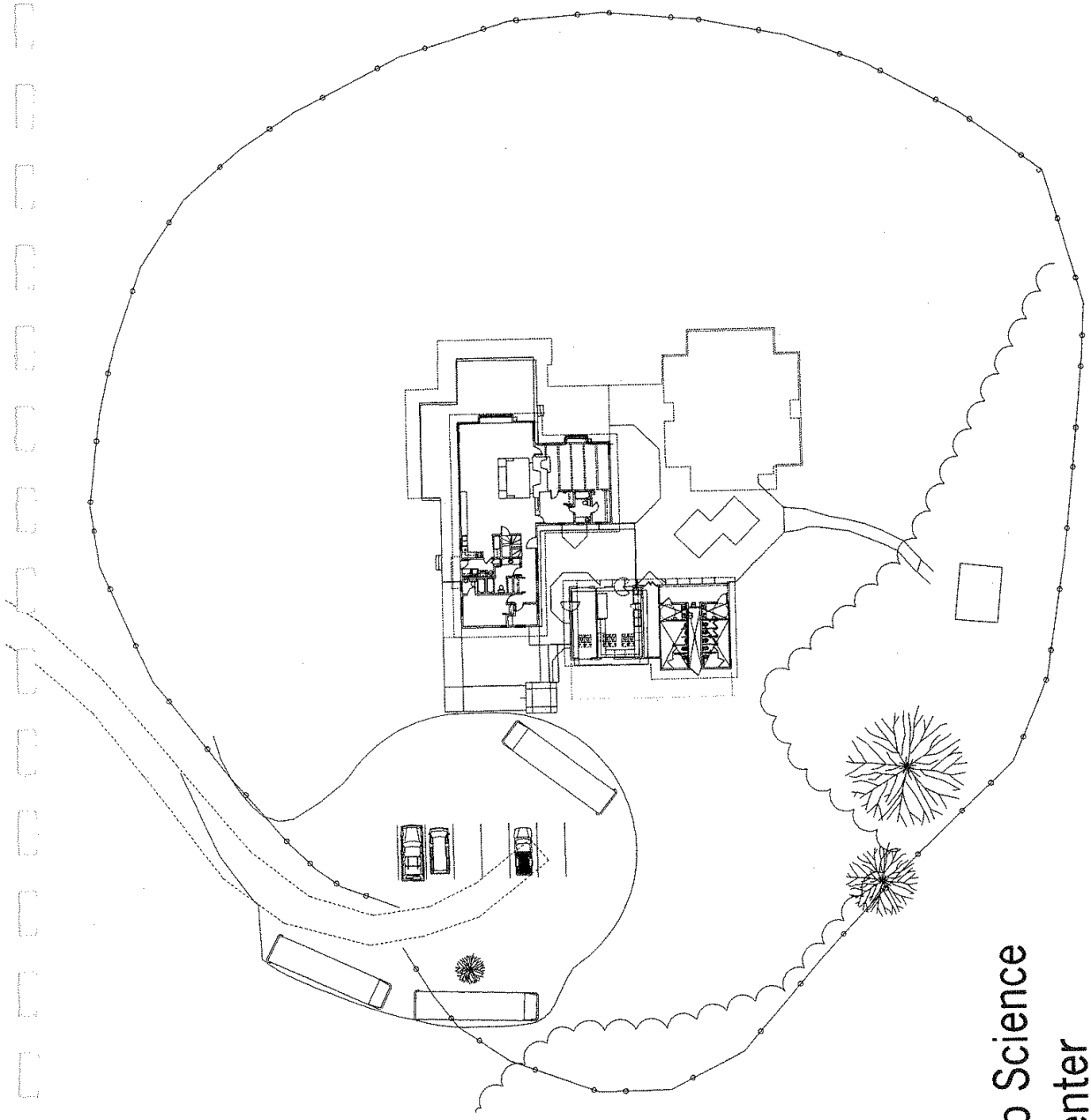
Newfound Gap


Park
Boundary
Little
Pigeon
Ranger
Station
Gate
Picnic
Area
Greenbrier Area
No Scale



Oconaluftee Job Corps

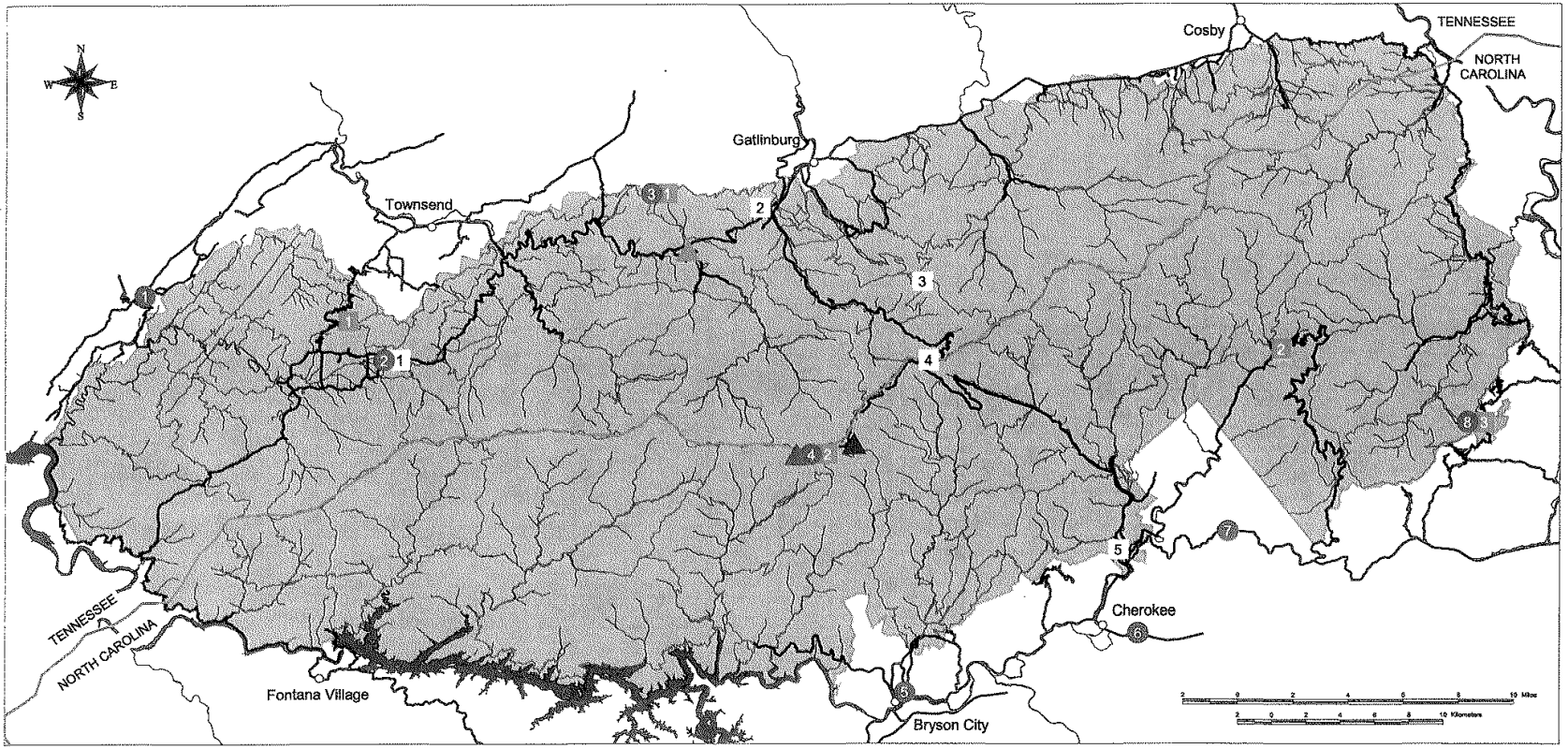

Seasonal Apartments
Residence
Dining Hall
Pavilion
Recreational Area
Dormitory
Gift Shop/ Administrative Offices
Pump House
LITTLE PRONG MIDDLE RIVER
Tremont Road
100 0 100 200
SCALE OF FEET
Great Smoky Mountains Institute at Tremont
Great Smoky Mountains National Park


Purchase Knob Science
Learning Center

APPENDIX C

AIR QUALITY MONITORING SITES AND DATA IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Air Quality Monitoring Sites In and Near Great Smoky Mountains National Park



- NATIONAL ATMOSPHERIC DEPOSITION PROGRAM AT ELKMONT (2,100') - precipitation chemistry
- NOLAND DIVIDE WATERSHED (5,700') - precipitation chemistry, meteorology
- EPA MOUNTAIN ACID DEPOSITION PROGRAM AT CLINGMANS DOME (6,660') - NDDN and cloud chemistry/deposition
- GASEOUS POLLUTANT MONITORING STATION (NPS, TVA, TN, NC and NOAA)
  1. Look Rock (2,700') - O_3, SO_2, CO, NO-NO_X, $PM_{2.5}$, visibility (camera, nephelometer, IMPROVE), NDDN, meteorology
  2. Cades Cove (1,850') - O_3, UV-B, meteorology
  3. Cove Mountain (4,150') - O_3, O_3 Flux, SO_2, CO, NO-NO_Y, $PM_{2.5}$, hydrocarbons, IMPROVE, meteorology
  4. Clingmans Dome (6,670') - O_3, meteorology
  5. Bryson City (1,900') - O_3, SO_2, $PM_{2.5}$
  6. Cherokee (2,100') - CO, $PM_{2.5}$
  7. Barnett Knob (4,700') - O_3, visibility (camera), meteorology
  8. The Purchase (4,900') - O_3, meteorology
- NOAA WEATHER STATION - meteorology
  1. Cove Mountain (4,150')
  2. Clingmans Dome (6,670')
  3. The Purchase (4,900')
- REMOTE AREA WEATHER SYSTEM (RAWS) - meteorology
  1. Indian Grave (2,600')
  2. Cherokee (3,380')
- PARK WEATHER STATION - temperature, precipitation
  1. Cades Cove (1,850')
  2. Park Headquarters (1,500')
  3. Mt. LeConte (6,500')
  4. Newfound Gap (5,040')
  5. Oconaluftee (2,100')

- Great Smoky Mountains National Park
- Large Lakes, Rivers
- Streams
- Roads
- Trails
- Cities, Towns
- State Boundary

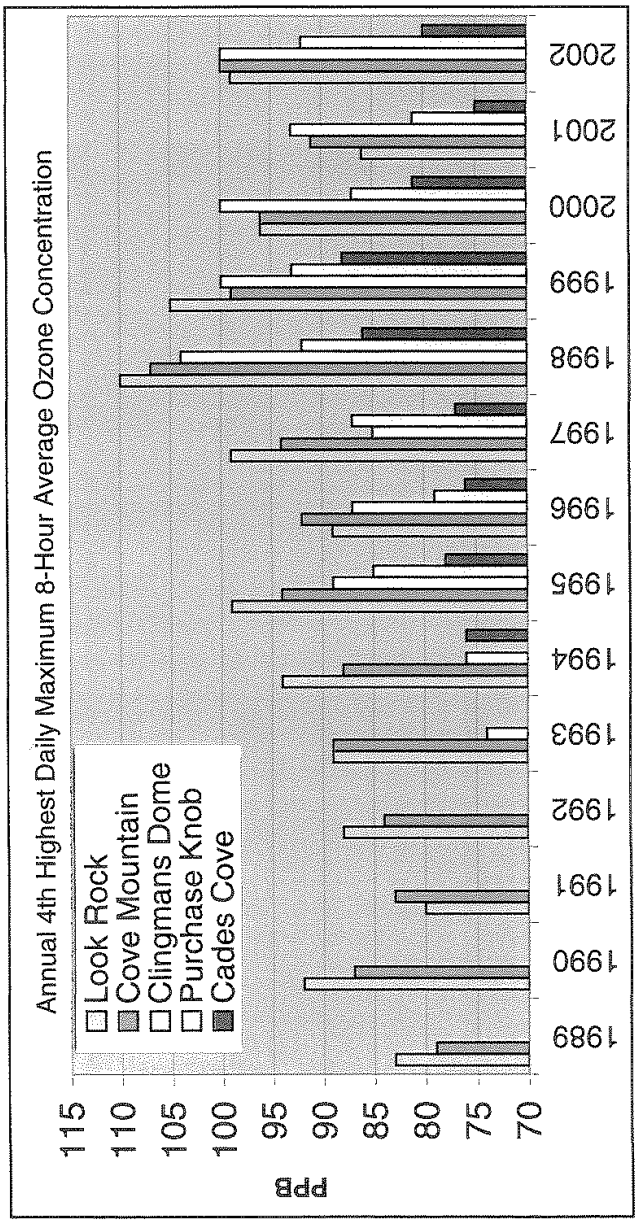
10-24-00

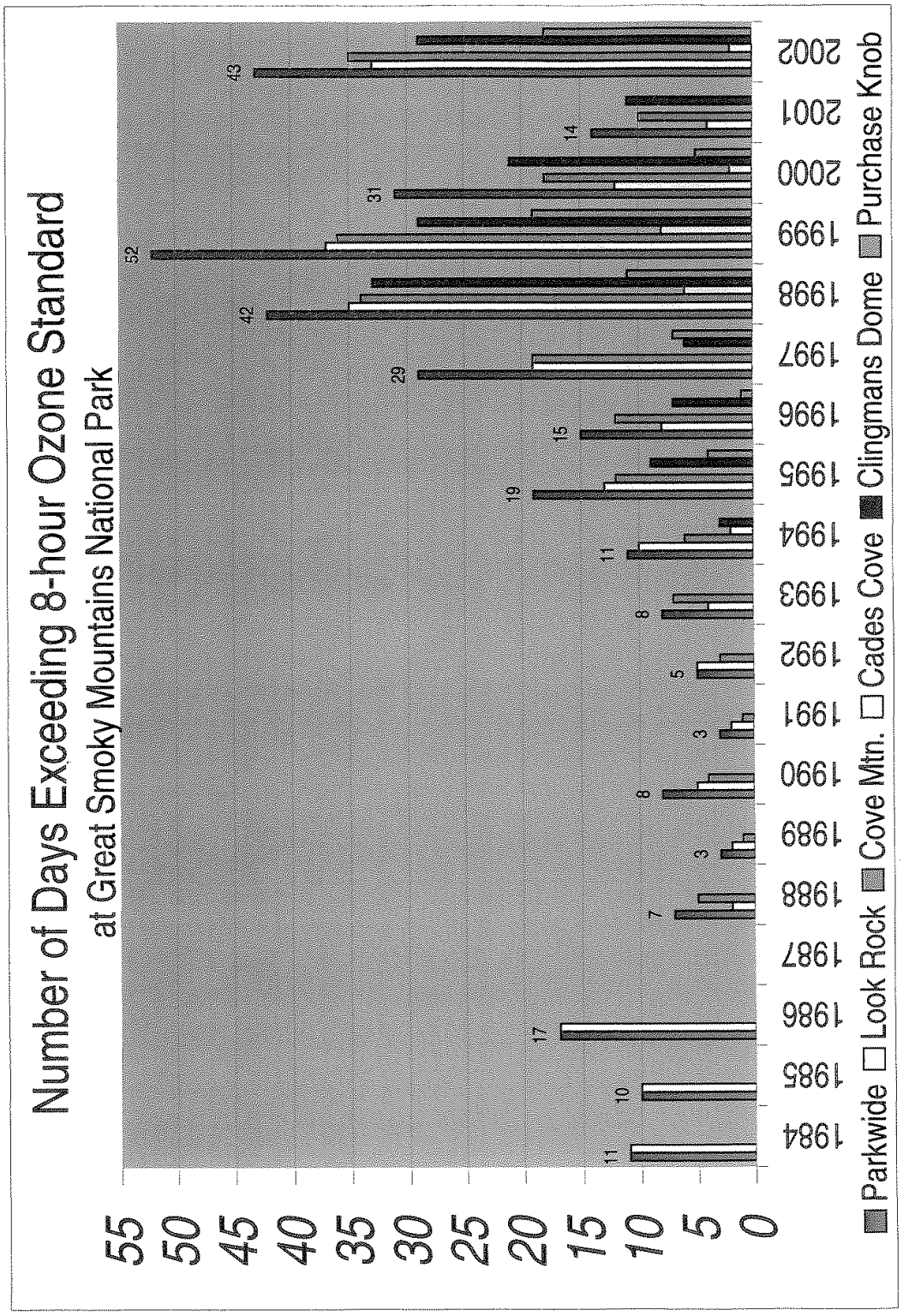
2002 Air Quality Monitoring Program at Great Smoky Mountains National Park, Tennessee/North Carolina

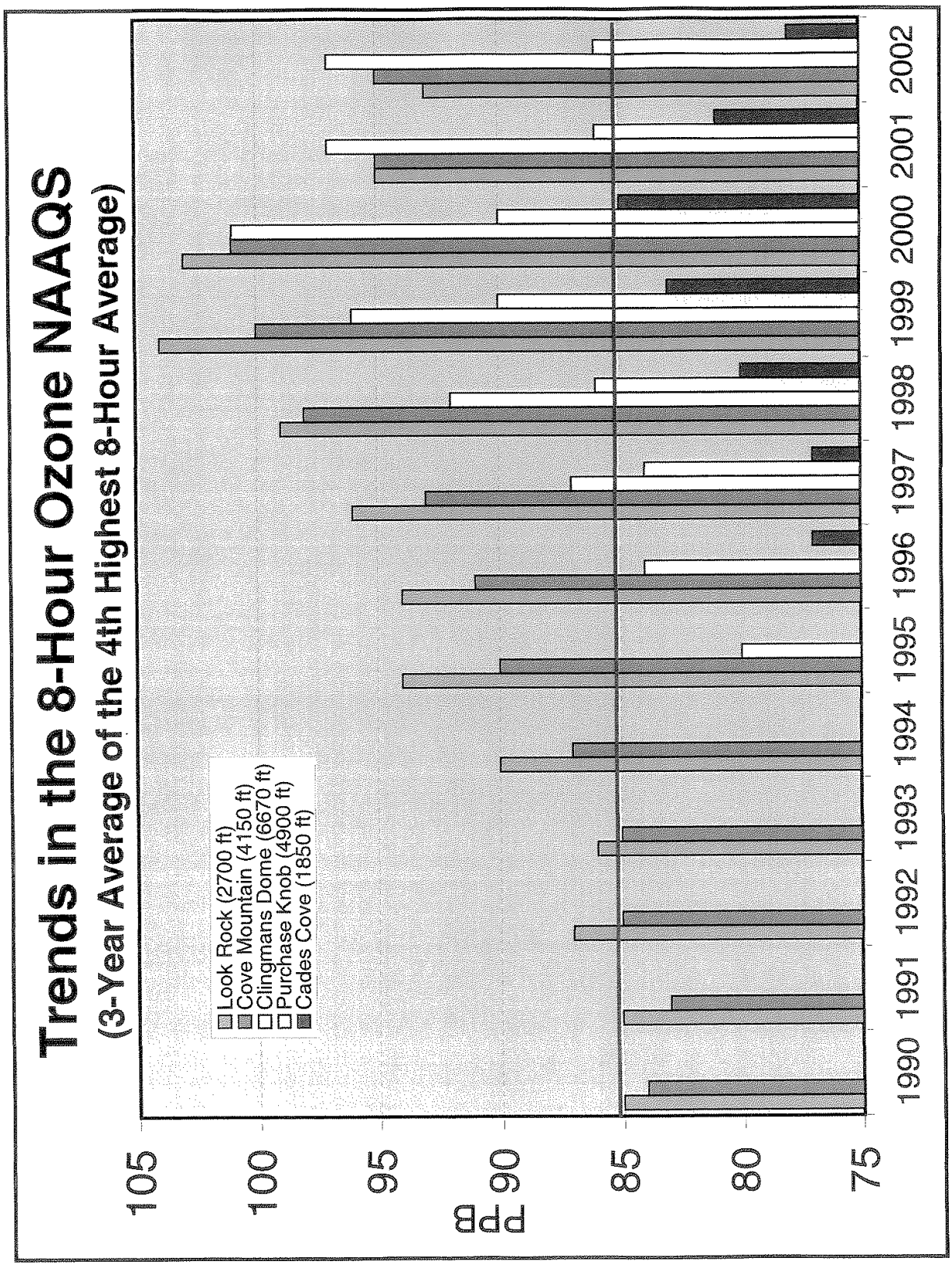
Site Name/Location/Cooperators/Start Year	Parameter(s)	Sampling Frequency/Duration
LOOK ROCK – 2700' (Blount Co, TN, Ridge) NPS (1984)	O_3, meteorology[1]	Hourly
NPS (1984)	$PM_{2.5}/PM_{10}$[2]	24-hour speciated PM (every day)
NPS, EPA, TN (2002)	$PM_{2.5}$ (mass only)[3]	Hourly (TEOM) planned for 2002
NPS (1993)	Nephelometer (B_{Scat})[2]	Hourly, 15-minute
NPS (1998)	Dry deposition[4]	Weekly average (Tue-Tue)
TVA	Speciated $PM_{2.5}$[5]	Hourly (real-time PM speciation)
CADES COVE–1850'(Blount Co, TN, Valley) NPS, NWS(1994)	O_3[1], meteorology[1,6]	Hourly[1], min/max temp, precip.[6]
NPS, EPA (1996)	UV-B[7]	Hourly
COVE MTN – 4150' (Sevier Co, TN, Ridge) NPS, NOAA (1986)	O_3, meteorology[1,8,14]	Hourly
NPS, TVA (1994)	O_3, SO_2, CO, NO-NO_y[1,8]	Hourly, 5-minute
NPS, TVA (2000)	$PM_{2.5}$, B_{Scat}[8]	Seasonal (daily PM; Hourly B_{Scat}
CLINGMANS DOME–6610'(Sevier Co, TN, Ridge) NPS (1993)	O_3, meteorology[1]	Hourly
NPS, EPA, TVA (1998)	Dry deposition[4]	Weekly average (Tue-Tue)
NPS, EPA, TVA (1994)	Cloud deposition[9]	Daily bulk
TVA, NPS (2002)	Mercury deposition[10]	Weekly bulk (Tue-Tue)
UT, W. Carolina U., Emory U. (2002)	$PM_{2.5}$[11] (mass only)	Hourly (portable continuous)
ELKMONT – 1850' (Sevier Co, TN, Valley) NPS (1980)	Wet deposition[12]	Weekly bulk (Tue-Tue)
NPS, TVA (2002)	Mercury deposition[10]	Weekly bulk (Tue-Tue)
HEADQUARTERS – 1500' (Sevier Co, TN, Valley) NWS, NPS	Meteorology[6]	Min/max temp, daily precipitation
MT. LECONTE – 6300' (Sevier Co, TN, Ridge) NWS, NPS	Meteorology[6]	Min/max temp, daily precipitation
OCONALUFTEE – 2000' (Swain CO, NC, Valley) NWS, NPS	Meteorology[6]	Min/max temp, daily precipitation
PURCHASE KNOB – 4900'(Haywood Co, NC, Ridge) NC, NOAA (1995)	O_3[13], met[14]	Hourly
BARNETT KNOB – 4700' (Jackson Co, NC, Ridge) NC (1998)	O_3, meteorology[13,15]	Hourly
BRYSON CITY – 1900' (Swain Co, NC, Valley) NC (1995)	O_3[13]	Hourly
NC (1998)	$PM_{2.5}/PM_{10}$[13]	24-hour speciated PM (3rd day)
NOLAND DIVIDE–5700'(Swain Co, NC, Ridge) NPS/UT(1991)	Wet/total deposition[1]	Weekly bulk (Tue-Tue)
NPS, UT (2000)	Meteorology[1]	Hourly
NEWFOUND GAP – 5020' (Swain Co, NC, Ridge) UT (2002)	O_3, meteorology[11]	Hourly (portable), partial day
UT, W. Carolina U., Emory U. (2002)	$PM_{2.5}$[11](mass only)	Hourly (portable), partial day
NWS, NPS	Meteorology[6]	Min/max temp, daily precipitation

1 Part of the NPS/GRSM Air Quality Monitoring Network
Meteorological measurements include wind speed/direction, relative humidity, temperature, solar radiation, and precipitation
2 Part of the Interagency Monitoring of Protected Visual Environments (IMPROVE)
Speciated particle measurements include filter-based SO_4, NO_3, NH_4, organics, elemental carbon, soil, ions, PM_{10}
3 Planned TEOM with NPS, EPA, TN
4 Part of the National Dry Deposition Network (NDDN)
Measurements include filter-based SO_2, SO_4, NO_3, NH_4, HNO_3
5 Possibly planned with TVA, Southern Company, DOE, EPRI, and NPS
6 Part of the National Weather Service (Remote Area Weather Stations)
7 Part of the Park's Research and Intensive Monitoring of Ecosystems Network (PRIMENet)
8 Part of the NPS and TVA Enhanced Gaseous Pollutant Monitoring
9 Part of the NPS, EPA, TVA Cloud-water Monitoring Program/ Clean Air Status and Trends Network (CASTNet)
Measurements include SO_4, NO_3, NH_4, H^+, Ca, Mg, K, Cl, cloud frequency, liquid water content, particle size
10 Part of the Mercury Deposition Network (MDN)
11 University of Tennessee, Western Carolina University, and Emory University Adult Day-Hiker Health Study
12 Part of the National Atmospheric Deposition Program (NADP)
Measurements include SO_4, NO_3, NH_4, H^+, inorganic N, pH, conductivity, major cations (Ca, Mg, K), precipitation volume
13 Part of the State of North Carolina Air Quality Monitoring Program (available in AIRS)
14 Part of National Oceanic and Atmospheric Administration (NOAA) East Tennessee Met Network
15 Part of the Cherokee Tribal Utilities Air Quality Monitoring Program

Prepared by Jim Renfro, Air Resource Specialist, National Park Service, Great Smoky Mountains National Park 1314 Cherokee Orchard Rd., Gatlinburg, Tennessee 37738, phone: 865/436-1708, fax: 865/430-4753, email: jim_renfro@nps.gov [Monitoring Info2.doc]


Annual 4th Highest Daily Maximum 8-Hour Average Ozone Concentration
Look Rock
Cove Mountain
Clingmans Dome
Purchase Knob
Cades Cove
PPB
115
110
105
100
95
90
85
80
75
70
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002


Number of Days Exceeding 8-hour Ozone Standard
at Great Smoky Mountains National Park
55
50
45
40
35
30
25
20
15
10
5
0
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
11
10
17
7
3
8
3
5
8
11
19
15
29
42
52
31
14
43
Parkwide
Look Rock
Cove Mtn.
Cades Cove
Clingmans Dome
Purchase Knob


Trends in the 8-Hour Ozone NAAQS
(3-Year Average of the 4th Highest 8-Hour Average)
Look Rock (2700 ft)
Cove Mountain (4150 ft)
Clingmans Dome (6670 ft)
Purchase Knob (4900 ft)
Cades Cove (1850 ft)
PPB
105
100
95
90
85
80
75
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002