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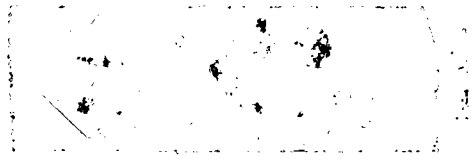
For:
The Biomass Energy Systems Branch
Division of Conservation and Solar Applications
The United States Department of Energy
Washington, DC 20545

ENVIRONMENTAL REPORT

ADVANCED SYSTEM DEMONSTRATION FOR UTILIZATION OF BIOMASS AS AN ENERGY SOURCE

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PREFACE

This volume summarizes the conclusions and findings of extensive analyses undertaken to assess the environmental impacts and effects of the U.S. Department of Energy's proposal to assist in an Advanced System Demonstration for Utilization of Biomass as an Energy Source. Included within this document are a description of the proposed project, a discussion of the existing environment that the project would affect, a summary of the project's impacts on the natural and human environments, a discussion of the project's relationships to other government policies and plans, and an extensive review of the alternatives which were considered in evaluating the proposed action. This volume discusses all findings of the research undertaken. More extensive presentations of the methods of analysis used to arrive at the various conclusions are available in ten topical technical appendices. These appendices include:

Appendix A: Project Description
Appendix B: Air Quality Studies
Appendix C: Water Quality Studies
Appendix D: Terrestrial Ecosystem Studies
Appendix E: Socioeconomic Studies
Appendix F: Transportation Studies
Appendix G: Land Use Studies
Appendix H: Recreation, Scenic, and Noise Studies
Appendix I: Historic, Archaeological, and Cultural Studies
Appendix J: Alternative Studies

ENVIRONMENTAL REPORT

Advanced System Demonstration for Utilization of Biomass as an Energy Source in Westbrook, Maine

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CHAPTER ONE: PROJECT DESCRIPTION

1.1 INTRODUCTION TO THE PROJECT

1.1.1 General Description

In June of 1977, the U.S. Department of Energy began a project for "Advanced System Demonstration for Utilization of Biomass as an Energy Source." After evaluation of the proposals submitted for carrying out this project, the Department of Energy chose to conduct a detailed study of a project designed to establish the technical and economic feasibility of harvesting and collecting low-quality wood and wood residues and converting them to industrial steam and electricity. The specific objectives of the program are to:

- establish that sufficient fuelwood can be collected at a reasonable cost to support and sustain such a plant;
- evaluate the energy system reliability and thermal efficiency;
- demonstrate that the energy produced from such a system with wood fuel would be available at a competitive cost; and
- evaluate the environmental and socioeconomic impacts of harvesting, collecting, and transporting fuelwood and operating the power plant.

The project was conceived by the Department of Energy to consist of three phases: 1) system design, financial analysis, and environmental assessment, 2) construction and start-up, and 3) operation and monitoring of costs and environmental impacts. Phase 1, which is now concluded, resulted in the completion of the tasks shown in Table 1.1.1-A. Reports discussing the detailed finings for each task are available from the Department of Energy and may be obtained by writing to:

Simon Friedrich
Biomass Energy Systems Branch
Division of Conservation and
Solar Applications
The U.S. Department of Energy
Washington, D.C.

TABLE 1.1.1-A: TASKS CONCLUDED IN PHASE I

1. Location of a reliable long-term source of fuel capable of providing 1,000 tons per day of fuel (oven-dry basis).
2. Selection of an existing harvest and collection system to provide the plant's daily fuel supply.
3. Preparation of detailed cost estimates for steps 1 and 2; determination of the price of wood fuel for the plant.
4. Selection of a suitable location for the plant.
5. Preparation of an engineering design for the plant.
6. Projection of capital and operating costs.
7. Preparation of an environmental report

After reviewing the products of Phase 1 and before moving on to Phase 2, several findings must be made by the Department of Energy. First, the objectives of the overall program must be found to be desirable in light of the environmental socioeconomic, engineering and financial analyses conducted in Phase 1. Second, adequate financial support for Phases 2 and 3 must be found to ensure that the construction, operation and monitoring of the proposed project can be accomplished in a manner which contributes to national energy goals. Finally, the cooperation of a private industrial concern is essential for the success of the demonstration project.

The cooperation of the S.D. Warren Company is not in itself essential to the continuation of the Advanced System Demonstration program. Its cooperation is neither implicitly nor explicitly assumed by the preparation and publication of this document.

1.1.2 Project Description and Need

Need for the Proposed Facility

The Department of Energy seeks to encourage the commercialization of alternative fuels capable of cost-effective substitution for increasingly scarce and expensive fuel oil. Wood residues have long been used to provide industrial steam. The Department of Energy now seeks to demonstrate that unused, low-quality wood, if harvested from the nation's forests, could supplement wood residues and that this fuel could replace the large quantities of fuel oil consumed by industrial facilities. Such a demonstration, if successful, could stimulate other manufacturing operations to convert to energy-efficient, cogeneration facilities burning low-quality wood to produce industrial steam and electricity.

This report examines the environmental, social and economic implications of the construction and operation of a wood-fired cogenerating, power plant. Twenty-two sites in Maine were the

subject of preliminary analysis and five sites were selected for detailed environmental and socioeconomic study. The S.D. Warren Co. mill in Westbrook, Maine was chosen for the final, in-depth investigation. The use of a single site for analysis provides a focus for detailed investigation; however the findings developed here have generic application to the industrial use of wood for energy throughout the country.

Concept of Operation

Figure 1.1.2-A provides a schematic representation of the concept of operations for the proposed wood-fired power plant. Forest residues will be harvested, chipped in the woods, and transported to the proposed plant site in large chip vans. Mill residues will be purchased from companies currently disposing of wood waste and shipped to the proposed plant by railcar or chip van. Approximately 15 percent of the fuelwood will arrive by rail; the remainder will be transported by chip van.

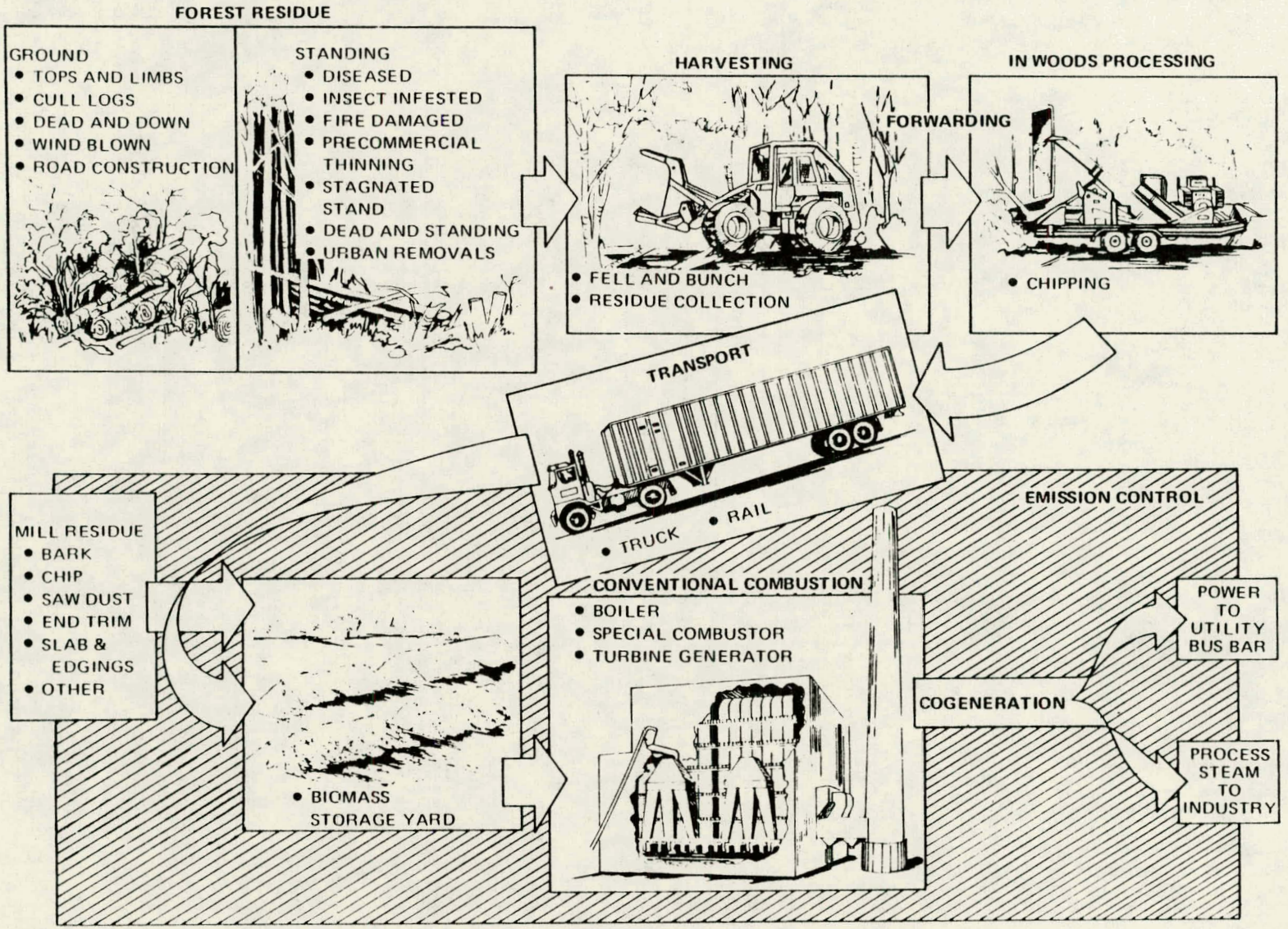
The facility is designed for continuous operation, twenty-four hours a day, seven days a week, for 340 days a year. The plant will shut down for scheduled maintenance and repair to assure continuous operation for the remaining 340 days.

The plant will require a fixed fuel supply rate of one thousand oven-dry tons per day of wood fuelstock which will be converted to heat to produce steam. The steam, in turn, will pass through a turbine-generator to generate electricity. Steam leaving the turbine will still have a substantial amount of heat energy that can be sold for process and heating purposes to the steam user. The proposed power plant will deliver electrical energy to the utility company to be sold in the same way as utility-generated power. Cogeneration of steam and electricity allows more efficient use of the wood fuel.

The plant will be controlled to balance the production of electrical energy such that the steam user will receive his needs first, and the remainder of the energy will be converted to electricity for the utility company. Under normal (i.e., average) design conditions, the facility will sell approximately twenty-six megawatts of energy to the steam user in the form of steam and

FIGURE 1.1.2-A:

Biomass Energy Flow Concepts



approximately eighteen megawatts of energy to the utility company as electricity. Approximately six megawatts of energy will be consumed by the internal operation of the generating plant. The energy balance will vary from season to season and at various times due to the fluctuations in requirements by the steam user. It is expected that the utility company will accept all excess power generation.

Process Description

The site layout for the proposed wood-fired power plant is shown in Figure 1.1.2-B and the relationships between the principal components of the system are schematically portrayed in Figure 1.1.2-C. The plant's design and operating features will be integrated into the existing S.D. Warren Company mill system to achieve the highest efficiency of energy production and utilization possible.

The woodyard will provide approximately one thousand oven dry tons of wood per day to the boiler. Since the wood actually received will be green and contain about 50 percent moisture, the fuel-handling and boiler system must be designed to handle two thousand tons of green fuelwood daily. Two thousand gallons of number 6 fuel oil will be fired daily to maintain a standby energy source in case of emergency. This will allow the boiler to remain on line without interruption of steam production. No more than 2.5 million gallons of number 6 fuel oil will be fired annually in the standby and emergency modes combined. The boiler will also be designed so that it can be readily retrofitted to burn coal.

The wood furnace will heat the boiler to produce 510,000 pounds per hour of steam for delivery to the turbine-generator. The turbine-generator will produce approximately twenty-four megawatts of electric energy and provide about 480,000 pounds per hour of steam at 560 and 50 pounds per square inch gauge (psig).

An air pollution system will be installed to cleanse the flue gases to a level that meets the applicable U.S. Environmental Protection Agency and Maine Department of Environmental Protection standards. Integrated with the stack emission system will be a

FIGURE 1.1.2-B: SITE LAYOUT

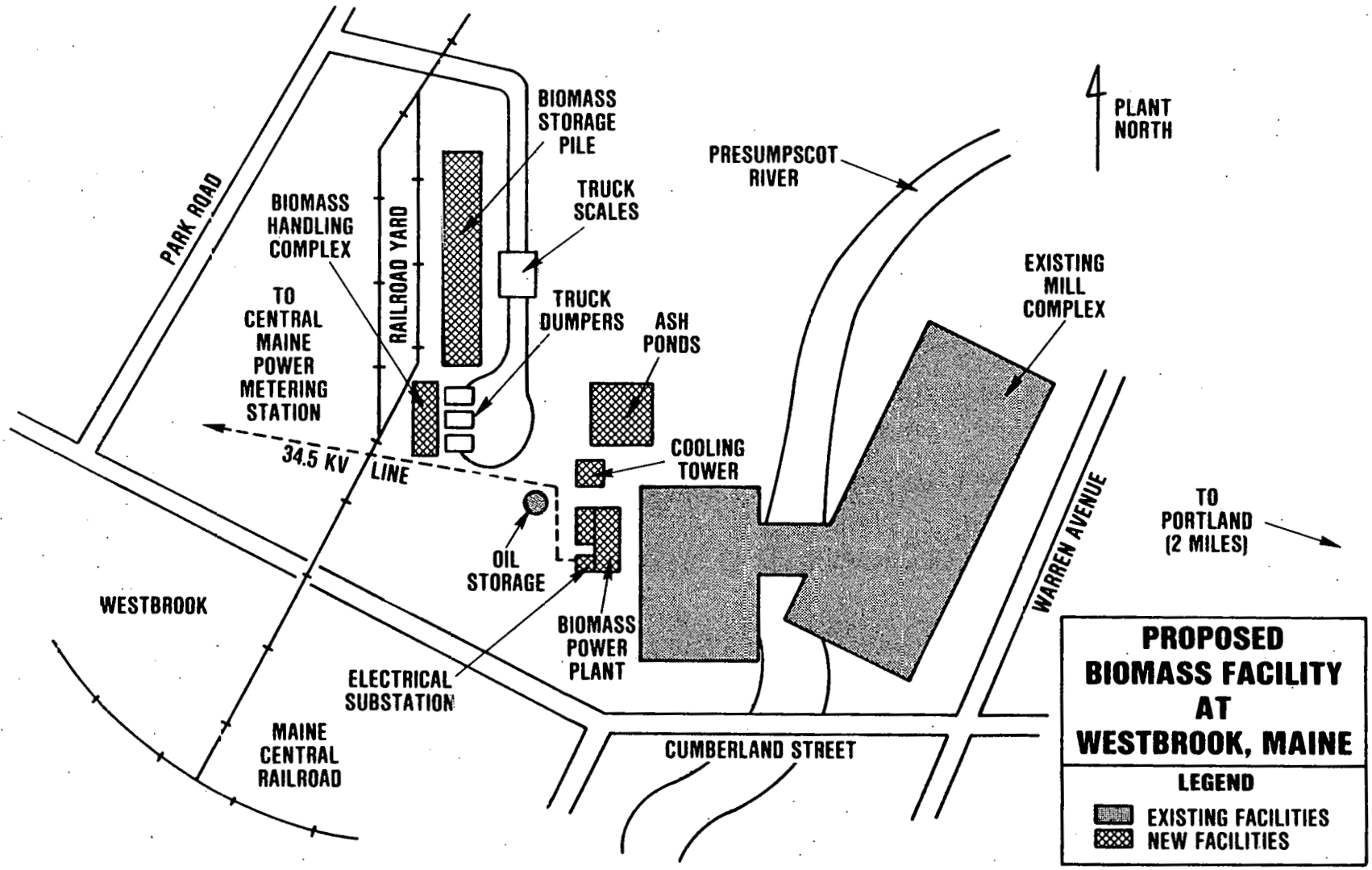
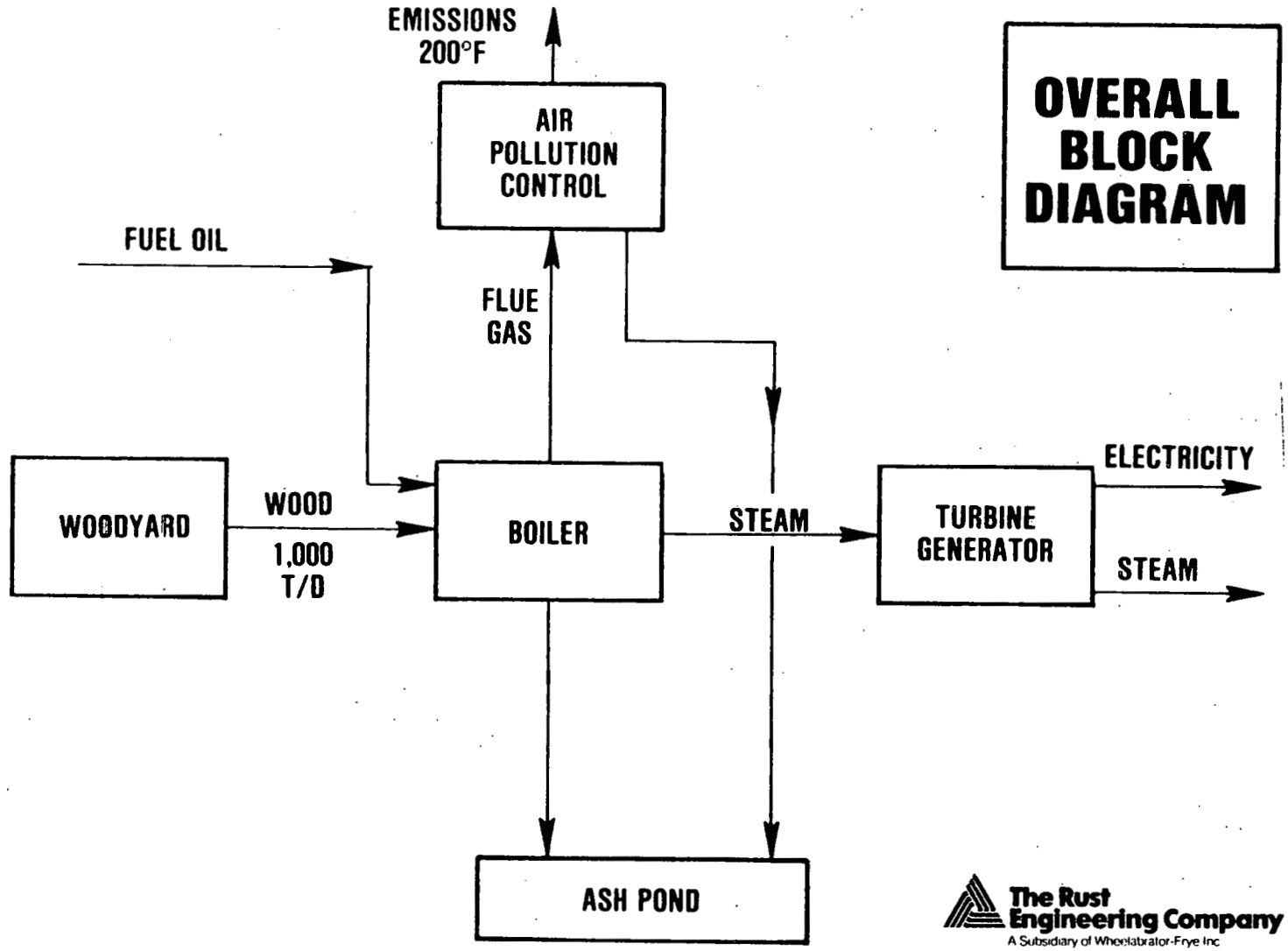


FIGURE 1.1.2-C: PRINCIPAL COMPONENTS OF THE SYSTEM



series of flue gas bark dryers that will predry the fuelwood as it is fed from the wood pile to the boiler. An ash pond will contain the ash sluiced from the boiler and the air pollution control equipment prior to the ash's ultimate disposal in a landfill. The water used to sluice the ash will be recycled to sluice additional ash.

1.2 FACILITY DESCRIPTION

1.2.1 External Appearance

The overall external appearance will be that of an uncluttered, functional industrial complex designed in keeping with modern architectural practice.

All of the major process functions will be housed in buildings and structures that fit the basic shapes of the process equipment. The walls and slanted roofs will be satin-finish aluminum panels designed for long-term service without painting or other surface treatment to maintain their attractive appearance indefinitely. The same basic design will be followed for all major structures, giving a unified, functional appearance to the entire complex.

Large wall surfaces will be broken by long vertical translucent panels designed to provide natural internal light and an attractive external appearance.

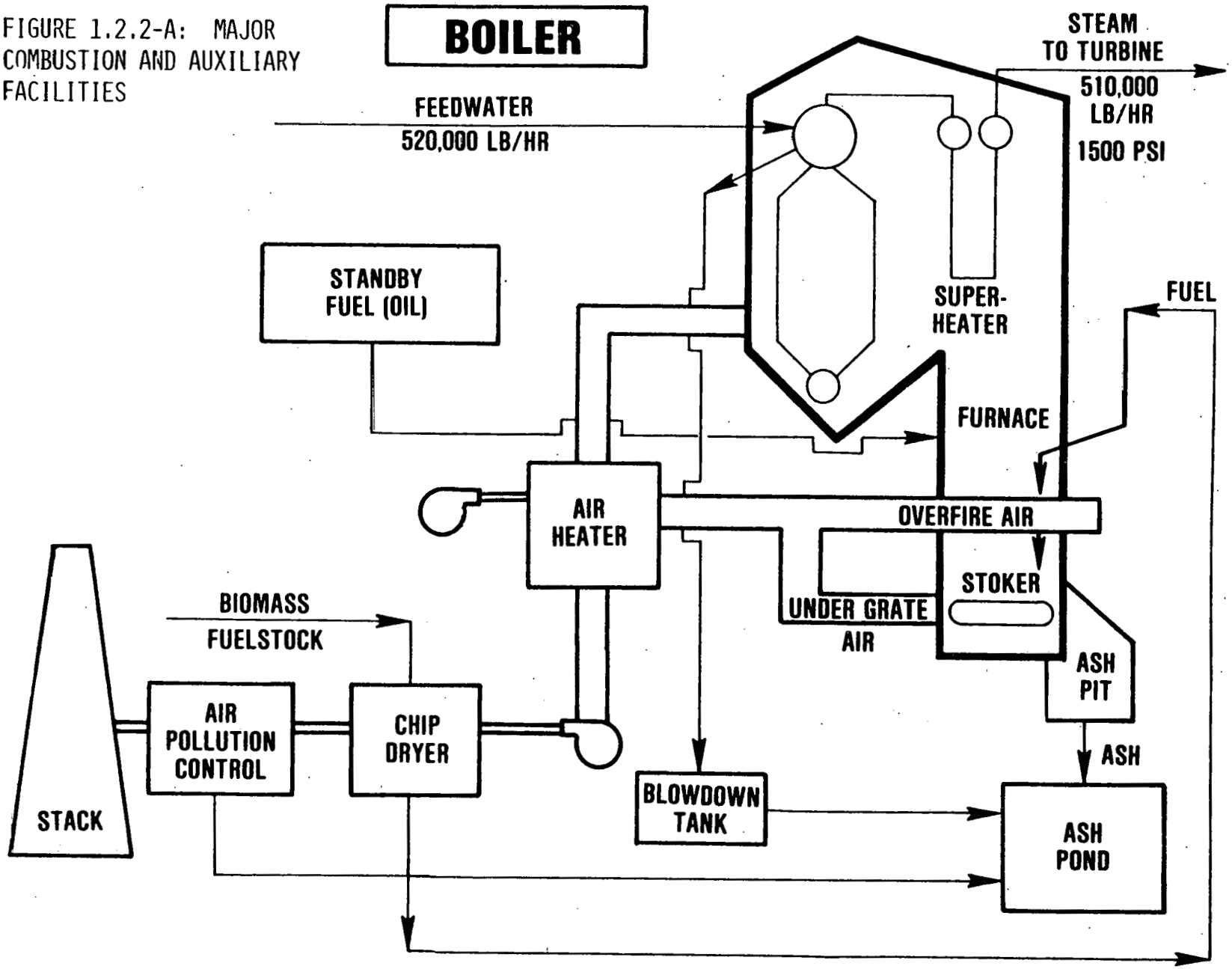
1.2.2 Steam-Electric System

Boiler Area

The boiler house will contain the major combustion and auxiliary facilities as shown in Figure 1.2.2-A. The fuel system will deliver chips to the furnace at the nominal rate of one thousand dry tons per day. A portion of the fuel will burn in suspension, but a stoker-grate will be used to assure complete burnout. Ash will fall into a water-impounded ash pit, where it will be conveyed hydraulically to the ash pond.

A superheater will provide greater efficiency and help achieve the desired steam temperature and pressure. Continuous and intermittent blowdown systems will ensure proper boiler operation. Exhaust gases will preheat combustion air for improved efficiency.

FIGURE 1.2.2-A: MAJOR COMBUSTION AND AUXILIARY FACILITIES



Overall efficiency of the boiler and its associated facilities will be approximately 73 percent.

Turbine-Generator Area

The turbine-generator will employ a double automatic extraction, condensing steam turbine, a 43-megawatt generator, and surface condenser shown in Figure 1.2.2-B.

Steam from the boiler will be admitted to the turbine nozzles. Partial extraction will occur at 560 psig and at 50 psig for delivery to S.D. Warren Company processing systems. These pressure levels match the needs of the customer's plant -- for example 560 psig for process uses, turbine-generators, and mechanical drive turbines, and 50 psig for process uses, heaters, dryers, and building heat. The flows have been carefully balanced to achieve the optimum arrangement from the customer's standpoint: no pressure-reducing stations will be employed under normal conditions.

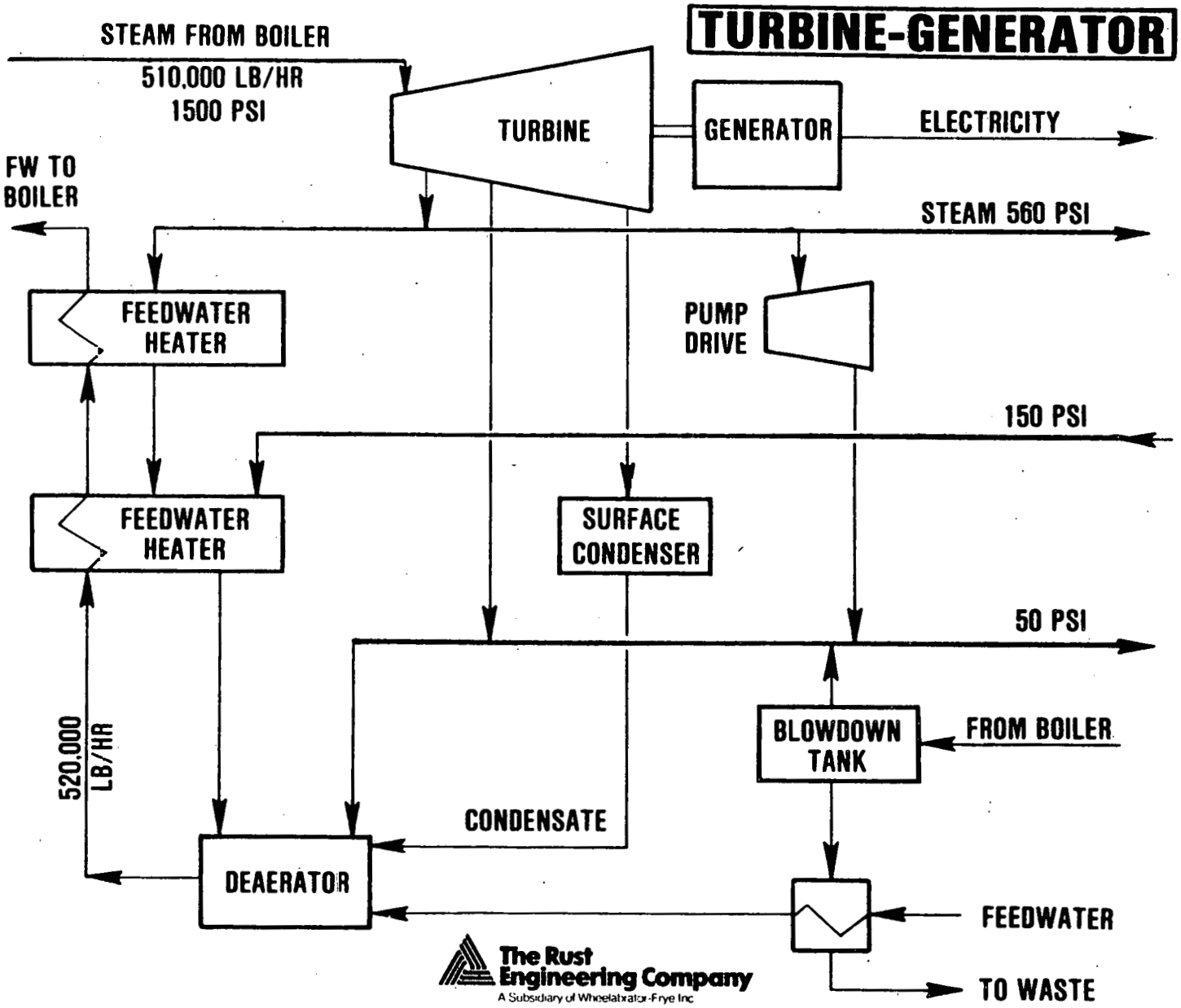
The surface condenser will condense up to 40 percent of the generated steam to meet the flexibility required when the customer's steam use is reduced; however, under normal conditions, less than 10 percent of the steam will be condensed. Lower flows to the condenser result in higher cycle thermal efficiency.

Steam-Electric Flows and Balances

Steam will be generated at 1,500 psig, 925°F, and a total flow of 510,000 pounds per hour to the turbine generator.

At design conditions, 266,586 pounds per hour will be extracted from the turbine at 560 psig for process use; 213,414 pounds per hour will be extracted at 50 psig, also for process use. The balance, 30,000 pounds per hour, will flow to the condenser. Under these flow conditions, the turbine will generate 25.5 megawatts of electrical energy at 13,800 volts. A small amount of steam will be taken from the steam drum for continuous blowdown and for intermittent steam sample stations.

FIGURE 1.2.2-B:


TURBINE-GENERATOR
STEAM FROM BOILER
510,000 LB/HR
1500 PSI
TURBINE
GENERATOR
ELECTRICITY
FW TO BOILER
STEAM 560 PSI
FEEDWATER HEATER
PUMP DRIVE
150 PSI
FEEDWATER HEATER
SURFACE CONDENSER
50 PSI
520,000 LB/HR
BLOWDOWN TANK
FROM BOILER
CONDENSATE
DEAERATOR
FEEDWATER
TO WASTE
The Rust Engineering Company
A Subsidiary of Wheelabrator-Frye Inc

1.2.3 Fuel Supply System

Biomass Fuel Supply

The Wood Energy Institute of Camden, Maine, has coordinated the preparation of the fuelwood availability study to provide data on the two major sources of fuel for the plant: forest fuel and millwood residues. Forest fuel for the plant will be procured from private logging contractors who in turn will purchase the timber cutting rights from landowners. Millwood residues will be purchased from wood products firms in the region. Because wood will be obtained from a wide variety of private sources, it is impossible to specify precisely the fuelwood procurement region. The extent of this region will depend upon the price paid for wood stumpage, wood transportation costs, the demand for wood from other sources, and the willingness of landowners to harvest timber. Therefore, primary and secondary harvest areas have been identified and caution has been used in specifying the availability of millwood residues.

James W. Sewall Company, using U.S. Forest Service data compiled in 1970 for Maine and 1973 for New Hampshire, prepared a fuelwood inventory for the area within a 50-mile radius of Westbrook, Maine. The results of this fuelwood inventory are summarized in Table 1.2.3-A. The annual production of tops and limbs within a 50 mile radius of Westbrook in Maine only could supply 1.9 times the plant's annual tonnage (see Table 1.2.3-B).

The Wheelabrator Cleanfuel Corporation (1979) extrapolated these figures to apply to the area within a 75-mile radius of Westbrook by assuming that the average timber growth in the expanded area is proportional to that within the 50-mile radius. The annual growth of tops and limbs alone in this region would be approximately 6 times the wood required to fuel the facility (see Table 1.2.3-C).

The timber growth and removal statistics developed for the area around Westbrook (50-mile radius, state of Maine only) show that the 1977 timber cut produced more than two-thirds of the

TABLE 1.2.3-A: FUELWOOD INVENTORY 50-MILE RADIUS OF WESTBROOK

Standing[1]		Green Tons
Boles		119,842,352
Tops and limbs		54,473,797
	Total	174,316,149
Annual Growth		
Boles		4,194,482
Tops and limbs[2]		1,906,483
	Total	6,101,065

1. *Trees 4 inches and up, diameter breast height.*
2. *2.8 times the annual plant fuel requirement of 680,000 green tons/year.*

Source: Wheelabrator 1979.

TABLE 1.2.3-B: FUELWOOD INVENTORY 50-MILE RADIUS OF WESTBROOK STATE OF MAINE ONLY

Standing[1]		Green Tons
Boles		84,365,120
Tops and limbs		38,347,781
	Total[2]	122,712,901
Annual Growth		
Boles		2,952,775
Tops and limbs		1,342,127[3]
	Total	4,294,947

1. *Trees 4 inches and up, diameter breast height.*
2. *70% of total in 50-mile radius.*
3. *1.9 times the annual plant fuel requirement of 680,000 green tons/year.*

Source: Wheelabrator 1979.

TABLE 1.2.3-C: ESTIMATED INVENTORY 75-MILE RADIUS OF WESTBROOK[1]

		Green Tons
Standing Trees[2]		
Boles		268,800,000
Tops and limbs		120,960,000
	Total	389,760,000
Annual Growth		
Boles		9,403,000
Tops and limbs		4,269,000
	Total	13,672,000

1. Based on 50-mile radius inventory
2. Trees 4 inches and up, diameter breast height.

Source: Wheelabrator 1979.

wood-fired plant's fuel needs in tops and limbs alone. This material currently is not being used. The excess growth over removals of trees in this area approximates three million green tons a year, as shown in Table 1.2.3-D.

Figures on the growth and removals for a 75-mile radius of Westbrook have been estimated, based on the data developed for the 50-mile radius (Wheelabrator 1979). These figures show that the tops and limbs currently being wasted could supply 1.8 times the annual fuel needs of the wood-fired facility. The excess growth in this area appears to be approximately ten million tons per year, as shown in Table 1.2.3-E.

The Wood Energy Institute prepared estimates of the rough and rotten standing timber within a 50-mile radius of Westbrook; this material totals 70 times the wood-fired plant's annual requirements for fuel. About two-thirds of this material is in Maine. The annual growth of rough and rotten timber within the 50-mile circle is estimated to be about 2.5 times the fuel required by the plant for a year. These figures are shown in Table 1.2.3-F. These estimates are based on incomplete data, but they indicate an order of magnitude of an additional source of fuel for the wood-fired power plant.

Data regarding currently unused wood in the forests within a 75-mile radius of Westbrook is summarized in Table 1.2.3-G. A number of wastewood sources--wasted tops and limbs, standing rough and rotten, or annual growth of rough and rotten--could fuel the proposed wood-fired power plant.

Mill residues could provide a second principal fuel source. Sawdust, bark, shavings, and slabs from sawmills and other forest products plants are materials that are of low commercial value and may be going to waste or creating a disposal problem. The Wood Energy Institute prepared and distributed a questionnaire that sought answers to such questions as how much mill residue is being produced, how much is available on a contract basis, what the current selling price is, and how much excess residue can be expected in the future. Questionnaires were sent to relatively large producers only and only those within a 100-mile radius of

TABLE 1.2.3-D: TIMBER GROWTH AND REMOVALS WITHIN 50-MILE RADIUS OF WESTBROOK STATE OF MAINE ONLY

Timber Cut - 1977[1]	Green Tons
Boles	953,270
Tops and limbs (wasted)	433,307
Total	1,386,575
Annual Growth	4,294,947
Less total cut	1,386,575
Excess growth	2,908,372

1. Trees 4 inches and up, diameter breast height.

Source: Wheelabrator 1979.

TABLE 1.2.3-E: ESTIMATED GROWTH AND REMOVALS WITHIN 75-MILE RADIUS OF WESTBROOK[1]

Timber Cut[2]	Green Tons
Boles	2,756,000
Tops and limbs (wasted)[3]	1,253,297
Total	4,009,297
Growth vs. Removals	
Annual growth	13,672,000
Total cut	4,009,297
Excess growth	9,662,703

1. Based on 1977 figures for Maine.
2. Factored from Maine data.
3. 1.8 times the annual plant fuel requirement of 680,000 green tons per year.
Source: Wheelabrator 1979.

TABLE 1.2.3-F: ROUGH AND ROTTEN TIMBER WITHIN 50-MILE RADIUS OF WESTBROOK

(Green tons)

	Standing	Annual Growth
Maine, 1972	30,511,888	1,067,916
New Hampshire, 1976	17,201,087	602,038
Total	47,712,969[1]	1,669,954[2]

1. 70 times plant requirement of 680,000 green tons/year.
2. 2.5 times plant requirement of 680,000 green tons/year.

Source: Wheelabrator 1979.

TABLE 1.2.3-G: SUMMARY OF UNUSED WOOD WITHIN 75-MILE RADIUS OF WESTBROOK[1]

	Green Tons	
Wasted tops and limbs	1,253,297	(1.8 times annual plant requirement)
Standing rough and rotten	106,877,000	(157 times annual plant requirement)
Annual growth--rough and rotten	3,740,000	(5 .5 times annual plant requirement)

1. Factored from 50-mile radius.
Source: Wheelabrator 1979.

Westbrook. As of this writing, responses have been received from 39 percent of these firms and the positive responses have been 28 percent. A positive response indicates that the firm has excess mill residue and would be willing to enter into a contract for selling this excess.

The positive responses indicated that a total of 405,000 green tons of mill residues could be obtained annually for an average cost of $5.63 per ton, as shown in Table 1.2.3-H.

Cost and availability figures have been developed further by determining the average hauling distance and the average cost per ton for transportation. If it is assumed that only 40 percent of the positive responses are actually placed under contract and if chips are eliminated because of their expense, the plant could obtain 20 percent of its annual fuel at a cost of $8.34 per ton--$3.93 for wood, $4.41 for transportation. These figures are shown in Table 1.2.3-I. It is estimated that twice the quantity of residues shown in Table 1.2.3-I is available within a radius of 150 miles of Westbrook, Maine (Wheelabrator 1979). These residues could come from such areas as Bucksport and Milo, Maine. Increased transportation costs will raise the cost of this material to $9.26 per ton. This increased quantity of residue could constitute approximately 40 percent of the 680,000 ton annual fuelwood requirement. For the purposes of analysis, the residue share of the annual fuel requirement is assumed to be 30 percent or approximately 200,000 green tons. The fuel source summary for the environmental analysis is shown in Table 1.2.3-J.

Biomass Fuel Handling

The fuel-handling facilities are shown diagramatically in Figure 1.2.3-A. Two sets of fuel-receiving equipment will be provided, one for chips that can be handled and stored without size reduction, the other for waste materials or chips that need to be screened and hogged if oversized.

The system designed for receiving chips will have two tilt-up truck dumpers, each of which can handle 40 tractor-trailer loads per day. The chips received by this system will go directly to the chip storage pile without any in-plant processing. The system

TABLE 1.2.3-H: WOOD ENERGY INSTITUTE POSITIVE RESPONSES TO SURVEY

	Annual Green Tons	Average Price/Ton
Sawdust	131,000	$3.00
Bark	155,000	4.43
Shavings	48,000	3.95
Slabs	14,000	7.02
Chips	57,000	15.99
Total	405,000	$ 5.63

Source: Wheelabrator 1979.

TABLE 1.2.3-I: MILL RESIDUE AVAILABLE TO PLANT, USING ONLY 40% OF POSITIVE RESPONSES

	Green Tons/ Year	Total Cost/Ton [1]	Total Cost/Year
Sawdust	52,400	$7.41	$388,284
Bark	62,000	8.84	548,080
Shavings	19,200	8.36	160,512
Slabs	5,600	11.43	64,009
Total	139,200	$ 8.34	$1,160,885

1. *Assumptions: average hauling distance - 63 miles; hauling cost - $.07/ton-mile.*

Source: Wheelabrator 1979.

TABLE 1.2.3-J: SUMMARY FUEL SOURCE FOR ENVIRONMENTAL ANALYSIS

Harvested Chips	480,000 tons/year
Mill Residue	200,000 tons/year
Total Wood	680,000 tons/year

Source: adapted from Wheelabrator 1979

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designed primarily for waste materials will have one tilt-up truck dumper and a clamshell bucket for railcar unloading. The materials received by this system will go to a primary screen that will separate the oversize materials from the acceptable materials. Oversize materials will be reduced in size by an operation called hogging and then blended with the materials passing the screen. The waste from the screen and hog will normally go to the storage pile, but can be routed through an alternate path that by-passes the storage pile and goes directly to the boiler.

The storage pile will hold about thirty days' supply of fuel and will have a "live" storage area with two reclaiming screw conveyors, each capable of providing 7,360 tons of fuel without any re-supply of the live storage area. The screw conveyors will take wood from the bottom of the pile. This procedure will make use of the heat from the biodegradation activity within the pile and avoid any snow or ice that may have accumulated on top of the pile. The screws will travel under the center of the pile for a total distance of some 960 feet or 96 percent of the pile length. An overhead conveyor belt with a traveling belt tripper will fill the storage pile; a small bulldozer will also be employed to spread the fuel and fill empty spaces.

The conveyors in the two receiving systems will handle 300 tons per hour; the storage pile conveyor will handle up to 450 tons per hour and the chip reclaiming system will supply 104 tons per hour. Electromagnets will be located at various points over the conveyors to remove tramp iron. Motorized gates and electrically operated controls will assure a smooth, uniform flow of fuel to the furnace.

Emergency Fuel Supply

Number 6 fuel oil will be fired continuously with the fuelwood at a rate of two thousand gallons per day (1.5 percent of the total Btu input) to ensure a readily available standby fuel system. This fuel system will be able to fire the boiler fully in the event of interruption of the fuelwood supply system. The furnace will include oil-burning nozzles and controls so that the switchover from fuelwood to fuel oil can be made smoothly and

rapidly. Operating in the standby and emergency modes combined, the furnace will fire no more than 2.5 million gallons of number 6 fuel oil per year (4 percent of the total annual Btu input).

1.2.4 Water Supply System

Cooling Water System

The power plant will employ a "closed cooling system," consisting of a cooling tower and circulating water pumps, a surface condenser serving the steam turbine, and auxiliary heat exchangers.

The primary source of water will be the S.D. Warren Company filtered water system. Flow will be continuous from this system in the form of make-up water to the cooling tower. About 225 gallons per minute (gpm) is required to compensate for tower blowdown, evaporation loss, and windage loss.

The tower will be a one- or two-cell, induced cross-flow tower, cooling 20,500 gpm. Water will enter the cooling tower at 100°F and under worst case conditions (ambient temperature of 73°F on a wet bulb thermometer) will be cooled to 90°F.

Circulating water will be pumped from the cooling tower basin by the circulating water pumps, through the surface condenser, and then back over the tower. Cooling water for the various auxiliary heat exchangers will be supplied from this system and returned to to cooling tower return water line.

A chlorination system in the cycle will minimize bacterial growth in the cooling water system.

Boiler Feedwater System

Feedwater treatment system. Boiler feedwater will be treated by an activated carbon filtration system followed by mixed bed ion exchange. The filtered water will be taken from the S.D. Warren Company filtered water system into a filtered water storage tank. From there, the filtered water will be pumped into the activated

carbon filter train and the mixed bed demineralizer train and then into the demineralized water storage tank. The water will then enter the boiler feedwater system.

The anion portion of the demineralizer bed will be regenerated by caustic soda (sodium hydroxide) and the cation portion by sulfuric acid. Suitable storage tanks for acid and caustic will be provided along with suitable metering pumps and controls. Backwash water from the regeneration cycles of the demineralizers will be discharged into the process wastewater system.

Feedwater supply system. Demineralized water will be pumped from the demineralized water storage tank, with a portion passing through the feedwater make-up heater. At all other times, the feedwater will leave the make-up heater and flow into the tray-type deaerator and then into the deaerator storage tank. Feedwater will be heated by condensing some steam from the 560-psig line and by using the 150-psig steam return from the S.D. Warren mill. The condensate from the two feedwater heaters will go to the deaerator for reuse in the feedwater system.

The motor-driven boiler feedwater pump will pump feedwater through two stages of high-pressure heaters and into the boiler. A turbine-driven boiler feedwater pump is included in the system in case of power failure.

Condensate from the condenser hot well will be returned to the system by the condensate pump, discharging into the deaerator. Demineralized water will be supplied to the steam user's system and condensate from this system will be returned to the condensate receiver and pumper from there to the deaerator.

Boiler water treatment chemicals such as hydrazine and morpholine will be introduced into the system between the deaerator and the boiler feedwater pumps to prevent corrosion in the boiler system and precipitate solids from the boiler water.

1.2.5 Water Effluent Treatment

Process Wastewater System

Process wastewaters consist of continuous and intermittent blowdown from the boiler, cooling tower blowdown, demineralizer backwash waters, and ash-sluicing water. All of these process wastewaters will be routed to the ash pond, where the solids will settle out. The clarified upper layers of water will be recirculated to the ash-sluicing system.

Fresh water will be added as required to make up losses due to evaporation. Any excess water built up in the system due to precipitation will be discharged through the existing S.D. Warren Company waste treatment system.

Sanitary Waste System

Sanitary facilities and a waste collection system will be provided. These facilities include water closets, lavatories, service sinks, and drinking fountains located in the two major buildings. The total flow will be approximately ten gallons per minute.

The sanitary wastes from these two buildings will be collected in sewer systems and routed to the existing sanitary facilities of the S.D. Warren Company. The line from the boiler house will be routed to the existing lift station, while the line from the woodyard building will go into an existing sewer line.

These wastewaters will ultimately flow into the municipal sewer system of the City of Westbrook.

1.2.6 Ash Disposal System

The ash disposal system is designed for collection and disposal of approximately eighty tons per day of ash from the furnace, dust from the mechanical dust collectors, and flyash from the electrostatic precipitators.

The ash-handling system will be a wet conveying and disposal system, utilizing ash ponding in an engineered earth basin, lined with impervious clay. Motive water for the ash sluice system will be decanted from the ash pond, pumped to a holding tank, and from there, pumped through the ash sluice system back to the ash pond.

Ash from the primary mechanical collector will be collected from the hopper system by a water ejector and hydraulically conveyed to the ash pond. Fly ash from the precipitator hoppers will be handled in the same way. The sifting hoppers' ash content will be aspirated by a water driven exhauster and discharged into the bottom ash hopper in a wet state. Ash from the bottom hoppers will be conveyed to the ash pond by a water-driven ejector system. Ash pond blowdown will be directed to the existing primary clarifier and then discharged through the wastewater system.

The ash pond will be divided into two basins, one of which is in service while the other is drying out and being cleaned for its next period of service. Each basin is designed for approximately six months' service and a six-month period is allowed for drying and ash removal. The ash will be removed after drying and transported by truck to a certified landfill.

1.2.7 Atmospheric Emission Control

Overall Control System

The air pollution control system has been designed to cleanse the flue gases to the level required to meet all applicable U.S. Environmental Protection Agency, U.S. Occupational Safety and Health Administration, and Maine Department of Environmental Protection air quality standards. It consists of mechanical collectors and an electrostatic precipitator, with discharge through a tall stack as shown in Figure 1.2.7-A.

There will be two mechanical collectors with a biomass predryer between them. The second mechanical collector will remove any sawdust that is entrained by the dryer. The dryer will

receive the wood at the top, allowing it to fall down through the upward flow of flue gas, which serves as the drying agent. The electrostatic precipitator has been selected for its high efficiency and low energy requirements. The combined system will remove 99.5 percent of the particulate matter entrained in the smoke steam.

An ash classifier will follow the mechanical collector to separate the large particulates of unburned carbon (char) for return to the combustion system, thus recovering some energy that would otherwise be lost. Noncombustibles will be sent to the ash pond for disposal. A stack three hundred feet tall will disperse the emissions, providing a discharge that meets applicable air pollution regulations controls.

Process Details

Flue gas from the boiler will first pass through a primary multiple tube mechanical dust collector, through the bark dryers, through the cyclone separators downstream of the bark dryers, through the electrostatic precipitator, through the induced draft fan, and out the stack.

Particulate matter collected in the primary mechanical collector will flow through rotary air locks to sand classifiers where sand and ash will be separated from combustible char. The sand and ash mixture will flow through a rotary air lock into a hopper and thence into the ash sluice system to the ash pond. A steam ejector will reinject combustible char into the furnace.

Particulate matter (wood) collected by the mechanical collectors will be discharged through a rotary air lock onto a bark conveyor which discharges into the bark distribution system. From here, the distributor air fan will blow the wood into the furnace. Fly ash collected in the precipitator will be discharged by rotary screws, through ash discharge valves, to the pneumatic conveying system, and then to the ash pond by hydraulic transport. Cleaned gases from the precipitator will be discharged to the stack through the induced draft fan.

1.2.8 Noise Control System

All work required and all equipment selected for installation in the plant will conform to the applicable regulations pertaining to noise abatement. Each piece of equipment that is capable of producing hazardous noise levels will be identified and the supplier will be required to certify that his equipment meets the applicable regulations.

Noise control engineering will be provided to reduce noise levels in work areas so that the resulting noise exposure of the employees during a normal, eight-hour day will meet the requirements of the Occupational Safety and Health Act of 1970.

Community noise from much of the plant equipment will be eliminated by weatherproof enclosure inside buildings. Railcar unloading, bark hogging and conveying operations are enclosed. The boiler components are contained within a closed building.

The forced draft fan will be fitted with splitter-type inlet silencers. Vendors of other equipment will be required to furnish noise level data. Silencers or quiet models will be purchased where the data indicates alteration is necessary to meet applicable regulations.

1.2.9 Transmission and Grid

The generator in the powerhouse will connect through switchgear to a substation adjacent to the powerhouse. This substation will step up the generator voltage from 13,800 volts to 34,500 volts for transmission to utility lines. A transmission line will be erected on an existing right-of-way and plant property to the utility metering station, approximately five thousand feet from the powerhouse. An existing transmission line running on this right-of-way will be removed once the new line has been placed in service.

The new transmission line will carry a maximum of forty megawatts and can be used for power transmission in either direction. When the power plant generator is taken out of service for maintenance, the transmission line can be used for power purchased from the utility -- Central Maine Power Company.

The switchgear in the powerhouse is also connected to a transformer that steps the voltage down to 11,000 volts, which is the distribution voltage for the S.D. Warren Mill. This interconnection will be a two-way service that allows the powerhouse to obtain power from other sources in the complex in case of outage or shut-down for maintenance.

1.2.10 Plant Secondary System

The secondary distribution system will be a radial type with no secondary tie between unit substations. Secondary distribution will be at 480 volts to motor control centers and 4,160 volts to medium voltage motor starters. The secondary system will have a high impedance resistor ground with a ground detector and traceable signal locator system.

1.2.11 Fire Protection System

The fire protection system for the Biomass complex will be patterned from systems used in the pulp and paper industries where considerable experience has been obtained over a long period of successful operation. The following is a brief description of the design.

Exterior Fire Protection

The existing underground fire main system will be extended around the chip storage pile with 10" mains and 6" laterals. Fire hydrants will be spaced 200 feet apart with a fully equipped hose

house at each hydrant. The fire main serving the Biomass complex will be connected to the city distribution system.

The chip storage pile will be limited to a 30 day capacity, and will be designed for a first-in first-out capability which will reduce fire hazards due to spontaneous combustion associated with long term storage of wood in a pile.

Interior Fire Protection

Automatic sprinkler systems will be provided in certain areas of the Biomass complex. A standard installation of automatic sprinklers designed as wet-pipe systems will be installed in the woodyard processing building and within all enclosed conveyors.

An automatic sprinkler system will be provided in the turbine building and designed to protect the oil system.

A standard installation of automatic sprinklers arranged as dry-pipe systems will be installed in the covered chip conveyor galleries.

The cooling tower will be protected by a deluge water spray system. The deluge value will be activated by pilot heads.

Hose stations will be installed in the following buildings:

a) Woodyard Building
b) Turbine Building - operating floor and basement
c) Power Complex Building - at firing end of boilers

1.2.12 Modifications to Existing Site Features

Roads

One existing paved road will be relocated to provide access to the truck scales and truck dumpers in the fuelstock-receiving area. A gravel road will be built for access to the ash ponds for ash pond cleaning and solid waste disposal. One existing road near the boilerhouse will be regraded and elevated. Otherwise, all of the existing roads at the complex will remain as they are.

Railroads

Some railroad track will be removed to make room for new facilities. A short length of track will be relocated to provide a length adequate for storage of ten railcars and the operation of the railcar puller for fuelstock received by rail.

Surface Drainage

Surface runoff in the area of the fuelstock unloading and storage facilities will flow by gravity into the ash pond, which will serve as a holding and surge basin for storm drainage. All other areas will drain into the existing treatment system at the complex.

1.3 OPERATIONAL MONITORING PROGRAMS

The U.S. Department of Energy recognizes that a lack of definitive knowledge about the environmental and economic implications of using energy sources which provide alternatives to oil could hinder the implementation of facilities employing these fuels. Consequently, in proposing to demonstrate the commercial viability of using harvested woody biomass to produce industrial steam and electricity, the Department of Energy also proposes to establish environmental monitoring programs to ensure careful observation of the environmental and economic effects of a wood-fired power plant. In addition to advancing knowledge of the impacts of using wood as a fuel source, the monitoring program may point to areas where the licensing and permitting procedures for wood-fired power plants could be streamlined.

1.3.1 Air Quality Monitoring

Lack of good data on the quantities of air pollutants emitted from well-controlled wood-fired boilers with the best available control technology may result in unnecessarily long ambient air quality monitoring periods prior to the issuance of preconstruction air quality licenses and permits. Data on carbon monoxide, nitrogen oxides, and hydrocarbon emissions from wood boilers are particularly weak. The Department of Energy proposes to cooperate with the U.S. Environmental Protection Agency and the Maine Department of Environmental Protection to monitor scientifically the emissions of all criteria pollutants (particulates, sulfur dioxide, carbon monoxide, nitrogen oxides, and hydrocarbons) from the stack of the proposed wood-fired boiler. Stack emissions will be monitored under varying boiler operating conditions and with varying mixtures of standby fuel (number 6 oil). The resulting data will be published, so as to be available to others planning the construction of wood-fired boilers. In addition, the data may form the basis for the Environmental Protection Agency to review

its emission factor estimates for wood-fired boilers.

The Department of Energy will also ensure that all ambient air quality monitoring required by the U.S. Environmental Protection Agency and the Maine Department of Environmental Protection, both prior to and after startup of the plant, will be conducted efficiently and completely.

1.3.2 Water Quality Monitoring

Data regarding the chemical composition of the water effluent from wood-fired boiler systems are difficult to obtain, though available analyses indicate that such effluent should be reasonably benign. The Department of Energy proposes to establish a program to determine the major chemical constituents, the trace elements, the suspended solids, and the biological oxygen demand of the water effluent resulting from different operating conditions and different mixtures of the primary and standby fuel. These measurements will be taken prior to treatment in the S.D. Warren Company secondary treatment facility. The resulting information will be published and otherwise made available to interested parties.

1.3.3 Ecological Monitoring

Inadequate knowledge about the impacts of whole-tree harvesting with varying rotations causes concern to the public in New England and throughout the nation. The Department of Energy proposes to cooperate with the U.S. Forest Service, the U.S. Environmental Protection Agency, appropriate state agencies, and interested landowners to monitor carefully the range of environmental impacts associated with the whole-tree harvesting of wood for the proposed plant. The program to be established will

examine the short- and long-term impacts on the soil, nutrient cycling, forest productivity, regeneration of forest stands, water quality, and wildlife populations. The resulting information will be published and otherwise made available to interested parties.

1.3.4 Ash Composition Monitoring

Lack of data on the composition of ash from wood-fired boilers raises public concern and may unduly increase the costs associated with locating landfills and disposing of ash. The Department of Energy proposes to conduct a program to determine the chemical and trace element composition of wood ash resulting from the combustion of varying mixtures of primary and standby fuel. This program will seek to determine any differences that exist between the combustion of bark alone, hardwoods alone, or softwoods alone. The results of these studies will be published and otherwise made available to interested parties.

1.3.5 Price of Energy

The Department of Energy will cooperate closely with the other involved parties to determine the cost of the steam and electricity produced by the proposed wood-fired power plant. This information will be made available to interested parties, as will information regarding methods by which the costs could be reduced.

1.4 REFERENCE

Wheelabrator 1979 — Wheelabrator Cleanfuel Corporation. Advanced System Demonstration for Utilization of Biomass an an Energy Source, Project status report of Contract EG-77-R-06- 1036, for the U.S. Department of Energy, Fuels from Biomass Systems Branch, Washington, DC (January 1979).

CHAPTER TWO: DESCRIPTION OF EXISTING ENVIRONMENT

2.1 PRESENT ENVIRONMENTAL SETTING OF PLANT SITE

2.1.1 Physiography

Location of Site

The plant site examined in phase I of the project is located entirely on the property of the S.D. Warren Company in Westbrook, Maine. This site is situated to the east of Park Road, north of Cumberland Street, and west of the Presumpscot River. The proposed boiler house would be constructed immediately to the west of the existing mill complex (which straddles the river). The locations of other facilities related to the wood-fired power plant are shown in Figure 1.1.2-B in Chapter 1. A paper mill and supporting facilities have been located on this site since 1845; it is already a highly disturbed, industrialized site.

Topography

Human activities on the plant site have substantially influenced its topography. The northeast corner of the S.D. Warren property is completely dominated by a large, flat-topped pile of bark and sludge, while on the northern perimeter a natural rise in the land has been extended as a result of the dumping of process clay. The natural terrain of the plant site is quite gentle. The land slopes smoothly down from about eighty feet above sea level at the Park Road property line to about forty feet at the banks of the Presumpscot.

Much of the mill property is close to the river and is subject to occasional flooding. The locations for the proposed boiler and chip pile lie above the elevation reached by floods of a magnitude expected to recur less often than every one hundred years (Labrecque 1978).

Soils

The surface material in the vicinity of the proposed wood-fired boiler comprises both fill and Melrose fine sandy loam (SCS 1974). This soil is a coarse sediment of glacial outwash origin, underlain by fine-textured sediments of marine origin, and is

characteristic of terraces adjacent to streams and rivers. Percolation is rapid in the upper layer and very slow in the lower. Runoff is medium and the soil presents severe erosion hazards (SCS 1974).

Elmwood fine sandy loam, a moderately well-drained soil, underlies most of the proposed chip pile site. Its origins and characteristics are similar to the Melrose soil, except that runoff is slow to medium and the water table lies near the surface at certain times of the year (SCS 1974). Occurring with the Elmwood soil is a patch of Swanton fine sandy loam. The two soils are comparable except that the latter is usually wet throughout the year (SCS 1974).

Geology

Surficial geology. The plant site at Westbrook is completely underlain by a thick layer of sensitive marine clays. This sensitivity was clearly demonstrated in 1886 by a massive flowslide which changed the course of the Presumpscot River (Gorrill 1975). There have been no problems with slides at the site since that time (Labrecque 1978). Sample profiles taken in the vicinity of the proposed facilities indicate considerable human disturbance in the form of landfill.

Bedrock geology. The bedrock underlying the area of the site is primarily composed of biotite quartzite and quartz biotite schists (Doyle 1967). Test borings on the site itself have encountered both mica schist and a metamorphosed micaceous sandstone with quartz intrusions (Gorrill 1962, 1969).

A major geologic structure of the Westbrook area is the "Westbrook lineament," an extension of the Nonesuch River Fault to the southwest. It is described as a "lineament" rather than as a "fault" because no real evidence of movement has been observed along its line (Hussey 1971).

Seismology

Westbrook lies close to the boundary between two seismic zones. The first is rated as a Level IV area on a seismic activity scale of one to five, meaning that thirty-two or more earthquakes of intensity VII or VIII on the Modified Mercalli Scale

have been recorded (see Table 2.1.1-A). The second seismic zone is a coastal area of Level II activity, where earthquakes are much less frequent (Hadley & Devine 1974).

Twenty-three earthquakes were recorded in Maine during the period 1817 to 1967. Nineteen were of Level IV or V on the Modified Mercalli Scale. Of the remaining four, all but one were Level VI quakes; the last was of Level VII and occurred in 1904. This tally does not take into account earthquake tremors experienced in Maine that have their epicenters in other areas, notably the St. Lawrence Valley (Coffman & von Hake 1972).

Nationally, Maine is rated two on a potential earthquake damage scale of one to three, meaning that quakes could cause "moderate" damage in the region (Coffman & von Hake 1972).

2.1.2 Climate

Climatic conditions exhibit substantial variability from one month to the next and, for any particular season, from one year to the next. It is said that for coastal Maine, the "normal" month is the exception. The alternate procession of cold, dry air masses from Canada and warm, moist air masses from the Gulf of Mexico, combined with a low incidence of cool, moist air masses from the ocean and a high storm frequency, produce weather at Westbrook that is characterized by change. Substantial changes in temperature, humidity, and wind direction occur approximately twice a week.

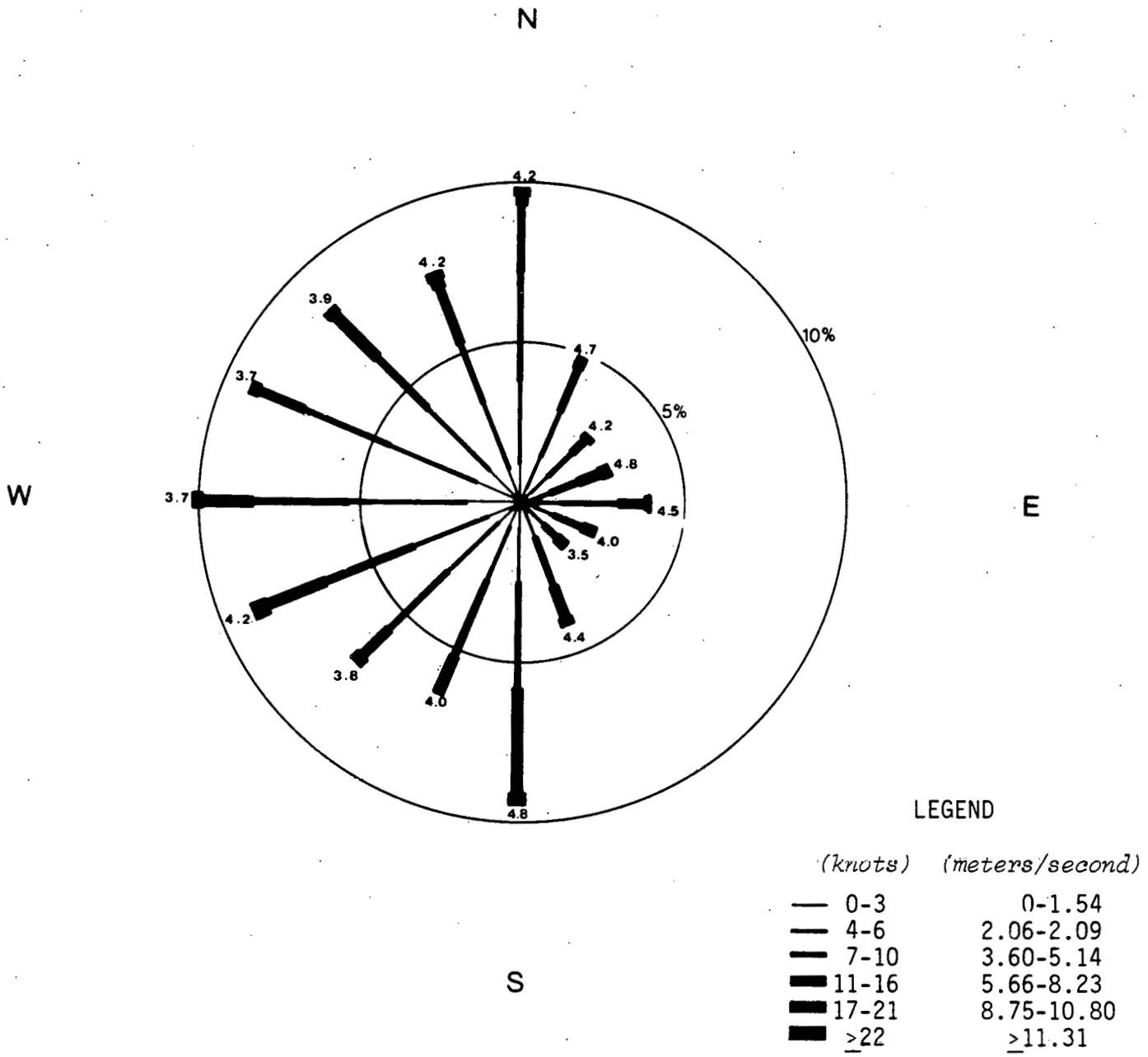
Prevailing winds at Westbrook are westerly (see Figure 2.1.2-A). During the winter season, northwesterly winds are common, although in the summer, a light south to southwesterly flow dominates. On an annual basis, winds are generally light; about 75 percent of hourly surface wind observations are less than 10 knots. The mean annual wind speed is 8.8 knots. The maximum monthly mean wind speeds occur in March and April and reflect the frequent occurrence of strong westerly and southerly winds during those months. Strong north or northwest winds accompany frontal passages in the winter months, while strong southerly winds may

TABLE 2.1.1-A: SUBJECTIVE DESCRIPTIONS OF SEVERAL LEVELS ON MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITY

Level	Description
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, and doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows, etc. broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings; great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Changes in well water. Persons driving motor cars disturbed.

Source: Coffman & von Hake 1972.

FIGURE 2.1.2-A: ANNUAL WIND FREQUENCY DISTRIBUTION IN PORTLAND[1,2]



1. *Annual mean values recorded at the Portland International Jetport averaged over 1960 to 1964. Numbers at ends of lines indicate mean wind speed from that direction, in meters/second. Width of lines indicates wind speed (see legend). Circles indicate frequency of winds from each direction.*
2. *The proposed site is located 3 1/2 miles northwest of the Portland International Jetport. The Jetport is 2 3/4 miles west of Portland Harbor; the proposed site is 5 1/2 miles west of the Harbor. The topography separating the two locations from the harbor and Casco Bay is essentially similar with maximum elevations of approximately 100 feet above mean sea level.*

Data from NOAA 1978.

precede the passage of cold fronts in summer. Sustained strong winds also accompany "northeasters," major wind and rain storms that may occur in fall or winter. The fastest one-hour wind speed observed prior to 1970 was 76 knots in March of 1947 and November of 1945. On both occasions, the wind direction was northeasterly (Lautzenheiser 1972).

During the summer months, cool, humid sea breezes are an important feature of the climate in the Portland region. They occur on cloudless days with strong solar heating and low pressure gradients. At the Portland airport, the breeze is generally southeasterly, lasting from 11:00 a.m. to 4:00 p.m. and reaching a maximum speed of 10 to 15 knots. The breezes frequently extend inland to Westbrook, but are of shorter duration there. Although the actual frequency of sea breezes at Portland has not been determined, they are said to occur between five and fifteen times per year (Rigney 1978).

On an annual basis, rain or snow occurs on about one-third of the days. Precipitation averages about forty-three inches annually and is equally distributed throughout the year (see Appendix B). Winter precipitation in Westbrook occurs as rain and wet snow. The average annual snowfall is seventy to eighty inches per year. Maximum accumulations tend to occur in early February, although the snow pack may disappear entirely in Westbrook during winter thaws.

The mean annual temperature at Portland for the period 1931 to 1960 was 45°F. The mean maximum temperature was 56°F, and the mean minimum was 34°F. July is the hottest month, with a mean temperature of 68°F, and a mean maximum temperature of 79°F. Monthly mean maximum temperatures exceed 70°F during June, July, August, and September. The coldest month is January with a mean minimum of 12°F.

Fogs occur at Portland airport with a relatively high frequency. During the period 1931 to 1960, fog occurrences averaged fifty-three per year and were most common in June, August, September, and October (see Appendix B). During the summer months, night fogs overland are usually due to the intrusion of

warm air from the ocean over the cold coast. These fogbanks often do not extend to Westbrook. In other seasons, fog is usually associated with rain or snow and is widespread throughout the region (Rigney 1979). The mean relative humidity at Portland is highest during the night and early morning hours. Mean values for 1:00 a.m. range from 79 percent in January to 91 percent in June (see Appendix B).

Average air mixing heights, which affect atmospheric dispersion of pollutants, range from 1,480 meters on spring and summer afternoons to 940 meters on winter afternoons. Morning mixing heights are lower, typically in the range of 500 to 600 meters (see Appendix B). Strong regional inversions related to large high pressure systems occur several times a year. Atmospheric inversions within 200 feet of the ground are frequently observed in the Portland region. Inversions of this type lasting four days or longer occurred on sixty-one occasions during the ten-year period from 1958 to 1967 (Holzworth 1972). The frequency of inversions is discussed in more detail in Appendix B.

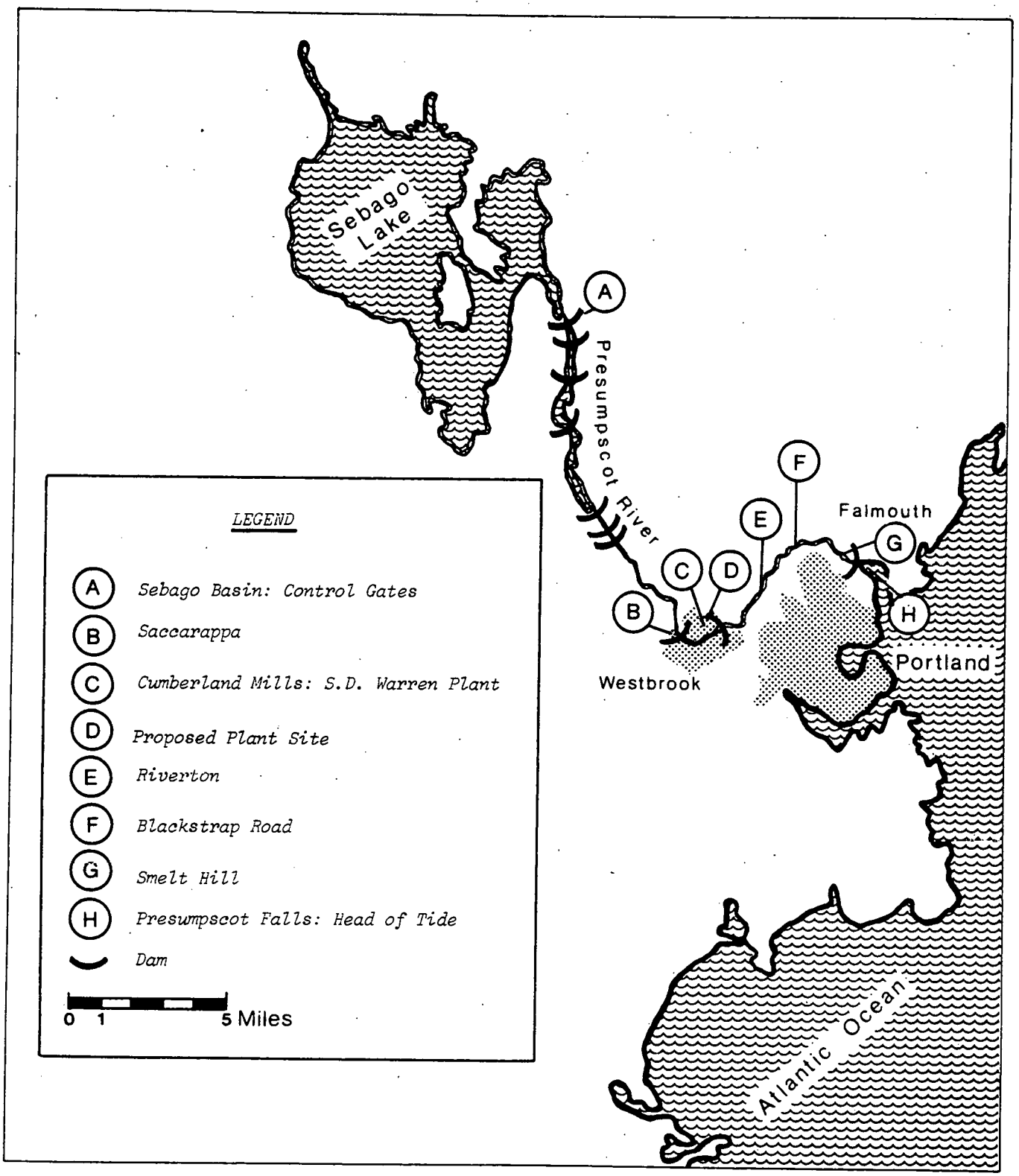
2.1.3 Hydrology and Water Resources

Presumpscot River

The Presumpscot River flows a total of 23.6 river miles from the outlet of Sebago Lake through Cumberland County to the outlet into Casco Bay at Falmouth. The proposed site is approximately 6.7 miles upstream from the river outlet (see Figure 2.1.3-A). The flow of the river is highly regulated by the control gates at Sebago Lake. These are operated by the S.D. Warren Company to assure adequate flow at the company's hydroelectric plants and to prevent flooding on Sebago Lake. Therefore, the Presumpscot River's flow is more even than those of other rivers and does not increase dramatically during the early April snowmelt period or decrease radically during late August and September. Hydrographs for the river are shown in Appendix C.

In the first week of July each year, the annual shutdown of the S. D. Warren plant causes an artificially generated period of

FIGURE 2.1.3-A: PRESUMPSCOT RIVER AREA



low flow. In the past, flow from Sebago Lake was completely stopped to allow for maintenance of plant property. Since 1976, an agreement with the Maine Department of Environmental Protection has required a minimum flow of 50 cubic feet per second (cfs) past Cumberland Mills during the shutdown period. In 1977 and 1978, this minimum proved to be sufficient to maintain critical levels of dissolved oxygen in the river's waters.

During the 1976 Water Year (October 1975 through September 1976), mean discharge out of Sebago Lake was 773 cfs, with a minimum of 0 cfs and a maximum of 1,110 cfs. At Blackstrap Road, the comparable figures were 1,167 cfs, 39 cfs, and 3,540 cfs (USGS 1977b).

The state of Maine has classified the Presumpscot River from Westbrook to the head of tide as a Class C waterway. Such waters are required to be suitable for all uses other than untreated drinking water and contact recreation. However, this stretch has also been designated by the state as a Water Quality Segment, indicating that it will not meet the above standards even with secondary treatment of municipal wastes and best practicable technological treatment of industrial discharges. The Presumpscot River is being reviewed by the state for classification as a cold water fishery, because Atlantic Salmon have been found in the river. Major water quality problems on the Presumpscot, as identified by the state (MBWQC 1977), are low dissolved oxygen, high turbidity, the presence of floating solids, excess oxygen demand from decomposing organic material accumulated on the riverbottom, bacterial contamination, and general unaesthetic conditions. Data for water quality in 1976, 1977, and 1978 are presented in Table 2.1.3-A.

The annual July shutdown of the S. D. Warren plant has created significant water quality problems because of the river's low flow. Table 2.1.3-B shows the comparison between 1976, 1977, and 1978 at this time of year; minimum flows at Blackstrap Road were 39, 90, and 50 cfs, respectively (S. D. Warren 1976, 1977, 1978). The recovery in water quality over this three-year period indicates that S.D. Warren's agreement with the state to main-

TABLE 2.1.3-A: WATER QUALITY DATA FOR PRESUMPSCOT RIVER STATIONS: 1976 AND 1977

(Monthly Averages)

	SACCARAPPA		CUMBERLAND		RIVERTON		SMELT HILL	
	1976	1977	1976	1977	1976	1977	1976	1977
Temperature (°C)								
May	NA	17.7	NA	17.4	NA	17.6	NA	17.6
June	21.6	17.8	22.1	17.8	22.1	17.7	21.9	17.5
July	23.16	23.23	22.9	23.3	23.1	23.5	22.3	23.0
August	21.82	23.18	21.7	23.3	22.1	23.5	21.8	23.2
Dissolved Oxygen (parts/million)								
May	NA	8.1	NA	7.42	NA	8.55	NA	8.62
June	8.34	9.26	8.1	9.32	7.86	9.34	5.6	8.74
July	8.21	8.5	8.05	8.27	7.94	8.06	5.91	7.4
August	8.32	8.56	8.23	8.16	8.51	8.18	7.59	7.68
Dissolved Oxygen (% saturation)								
May	NA	84.54	NA	76.7	NA	89.1	NA	89.88
June	93.7	96.77	91.9	97.2	89.2	97.3	63.0	90.6
July	95.0	98.33	92.7	95.9	91.6	93.9	68.0	82.25
August	93.8	99.13	92.7	94.7	96.7	95.0	85.4	88.9
pH								
May	NA	NA	NA	6.6	NA	6.9	NA	7.0
June	NA	NA	7.3	6.6	7.2	6.6	7.1	6.7
July	NA	NA	7.0	6.67	6.93	7.0	6.87	6.97
August	NA	NA	6.95	6.72	6.85	7.13	7.0	6.9
Total Solids (tons/day)								
May	NA	NA	NA	80.9	NA	121.3	NA	80.9
June	NA	NA	54.4	42.5	178.0	82.5	192.9	103.7
July	NA	NA	59.3	53.9	122.6	147.7	98.9	107.8
August	NA	NA	71.7	36.4	92.2	94.4	116.2	101.4
Fecal Coliform (#/100 ml)								
May	NA	NA	NA	600	NA	2,600	NA	4,500
June	NA	NA	NA	1,867	NA	1,000	NA	1,167
July	NA	NA	NA	7,233	NA	35,800	NA	9,233
August	NA	NA	NA	9,400	NA	9,633	NA	15,300

NA indicates data not available.

Source: S. D. Warren 1976, 1977.

TABLE 2.1.3-B: DISSOLVED OXYGEN IN PRESUMPSCOT RIVER DURING JULY SHUTDOWN PERIOD

	CUMBERLAND			RIVERTON			BLACKSTRAP			SMELT HILL		
	1976	1977	1978	1976	1977	1978	1976	1977	1978	1976	1977	1978
Parts/million	7.5	7.7	8.38	3.8	7.4	8.17	0.2	6.6	7.64	2.0	7.9	7.28
% Saturation	86.0	88.0	92.9	43.3	84.0	89.74	2.3	74.6	83.9	22.9	90.2	80.44

Source: S. D. Warren 1976, 1977, 1978.

tain a minimum flow of at least 50 cfs at Cumberland has resulted in more satisfactory water quality. Without such augmented flow, the Presumpscot River would not meet the state's water quality requirement of five ppm dissolved oxygen for Class.

The S.D. Warren Company is the only major consumer of Presumpscot River water. Approximately seventeen million gallons are extracted per day at Cumberland Mills (Labrecque 1978). Immediately following major storm events, the company sometimes shifts from the river to the Portland Water District for its water supply. This shift is necessary because accelerated runoff may increase suspended and dissolved solids, making the water unsuitable for the production of paper products.

The Presumpscot River is also used for hydroelectric generation. Seven dams currently use 230 feet of the total 270-foot drop from Sebago Lake to Falmouth. Central Maine Power Company operates one of these dams; the S.D. Warren Company operates the remaining six (Rolfe 1978).

Ground Water Resources

All of the surface geological strata of the lower Presumpscot Basin contain some ground water. The highest yielding layers are those created by stratified deposition from glacial waters. Water supply from marine clay deposits is very low, rendering these deposits of little importance as a supply aquifers. Within two miles of the proposed site, only ten wells are found, all used for domestic supply.

2.1.4 Ambient Air Quality

Although there are numerous atmospheric pollutants that affect air quality, there are six designated criteria pollutants normally used as indicators of overall air quality. These criteria pollutants are total suspended particulates, sulfur dioxide, nitrogen oxides, carbon monoxide, lead, and ozone. Although there is no absolute certainty as to what levels of pollution constitute unacceptable deterioration of air quality, the federal and state governments have established ambient air quality stand-

ards based on best available scientific evidence and social and economic necessity. These standards provide a frame of reference for the assessment of air quality and its implications for human health and welfare. For this project the ambient air quality was assessed for five of six criteria pollutants relative to the National Ambient Air Quality Standards and Maine Ambient Air Quality Standards (see Appendix B).

Moderately high short-term particulate levels have been recorded in downtown Portland. Annual mean particulate concentrations approaching or even slightly exceeding the Maine annual standard have occurred (see Appendix B). However, further away from the city center particulate concentrations are generally much lower: annual mean concentrations are roughly half those mandated by the Maine annual standards (see Table 2.1.4-A). These values are probably typical of Westbrook as well.

Sulfur dioxide values in the Portland area have exceeded national ambient air quality standards in past years (see Appendix B). However, these violations occurred only in a relatively small area of downtown Portland, and a recently mandated shift to low-sulfur fuel oil has led to a reduction of urban sulfur dioxide concentrations. Elsewhere in the metropolitan Portland Air Quality Region, sulfur dioxide levels have been consistently low, with the lowest values observed in the suburbs. During the period 1973 to 1977, the annual mean sulfur dioxide concentration measured in Westbrook was 15 micrograms per cubic meter ($\mu g/m^3$). The applicable national standard is 80 $\mu g/m^3$. Mean sulfur dioxide values for other averaging times are similarly lower than the corresponding ambient air quality standards (Johnson 1978).

Nitrogen dioxide concentrations have not been extensively monitored in the Portland Air Quality Region, but the available data suggest that annual mean concentrations (the only averaging time for which national standards apply) are roughly half of the allowable level. Limited data for Westbrook support this conclusion (see Appendix B).

TABLE 2.1.4-A: PARTICULATE CONCENTRATIONS OBSERVED NEAR WESTBROOK

Site	Year	No. of Observations	Annual Mean Concentration (µg/cu m)	Maine Annual Standard (µg/cu m)
Riverton School	1976	5	29	50
	1977	55	32	
	1978	31	27	
Lyseth School	1972	3	17	50
	1973	56	31	
	1974	58	32	
	1975	58	33	
	1976	49	30	

Source: EPA 1979.

Carbon monoxide levels have not been monitored for sufficient periods of time to establish ambient levels. Nevertheless, the lack of extreme congestion of automobile traffic and the good ventilation of the area as a whole suggest that carbon monoxide concentrations in Westbrook should not exceed standards (see Appendix B).

Ozone concentrations in the Portland region have been recorded by the Maine Department of Environmental Protection at three different sites for one or two summer seasons each. The concentrations at all locations are frequently high; ozone concentrations at the Cape Elizabeth site are consistently higher than at either Gray or North Bridgton, both of which are further inland. Multiple violations of the old national air quality standard of 160 $\mu g/m^3$ were observed at each site during May, June, July, August, and sometimes September (see Table 2.1.4-B). The federal ambient ozone standard was recently increased from 160 $\mu g/m^3$ to 235 $\mu g/m^3$, and the criteria for determining attainment or nonattainment also changed (FR 1979). It is expected that Maine will adopt this change. The modification of the standard may result in the reclassification of the North Bridgton area as a compliance zone under the new standard. The number of violations at Cape Elizabeth likewise will diminish significantly, although concentrations in this area will still violate federal and state standards.

Suitable long-term ozone data are not available for Westbrook although short-period records from 1978 indicate that day-to-day ozone concentrations at Westbrook are closely correlated with those at North Bridgton and are consistently lower than those at Cape Elizabeth (see Appendix B). Based on the existing summertime ozone measurements for North Bridgton, summertime ozone concentrations in Westbrook should average about 40 to 60 $\mu g/m^3$ with a one-hour maximum of approximately 240 $\mu g/m^3$ (see Appendix B).

At present, in accordance with Section 107 of the Clean Air Act as amended in August 1977, the Maine Department of Environmental Protection has classified the Metropolitan Portland Air

TABLE 2.1.4-B: OZONE CONCENTRATIONS IN THE WESTBROOK AREA

Site	Year	Month	Mean Concentration (µg/cu m)	Range (µg/cu m)	Hours Exceeding Old Standard[1]	Hours Exceeding New Standard[2]
Gray	1977	May	74	0-218	10	0
		June	65	0-336	11	4
		July	48	0-175	2	0
Cape Elizabeth	1977	May	115	17-373	100	24
		June	86	10-390	30	7
		July	94	13-325	92	7
		August	100	0-450	110	41
		Sept.	59	5-165	1	0
	1978	May	94	10-245	45	3
		June	80	10-245	38	1
		July	86	10-392	78	28
		August	65	10-255	24	3
		Sept.	57	0-216	10	0
North Bridgton	1978	July	64	10-216	23	0
		August	59	0-235	21	2
		Sept.	40	0-137	0	0

---

1. Old national ambient air quality standard = 160 µg/cu m.
2. New standard (as of February 1979) = 235 µg/cu m.

Calculated from MDEP 1977, 1978.

Quality Region as an attainment area for total suspended particulates, sulfur dioxide, and nitrogen oxides, as unclassified for carbon monoxide, and as a nonattainment area for ozone (MDEP 1979).

2.1.5 Terrestrial Ecology

The S.D. Warren Property, location of the proposed plant, is developed, paved, or otherwise disturbed, with the exception of a small patch of woodland at the northern end of the property. The areas that would be directly impacted by the plant are characterized by annual and perennial herbaceous "weeds" -- that is, plants that colonize disturbed areas. Some of these plants are native, some alien. In the few low damp spots on the site, species differ from the general trend but otherwise there are no discernible distribution patterns. Although the species diversity is high, the vegetative species present on the site are extremely common and can be found on any vacant lot, roadside, or power-line right-of-way in the Northeast. No species were found that could in any way be construed as rare, endangered, or otherwise worthy of protection.

The small woodlot is dominated by white pine on the north-facing slope and red oak on the south-facing slope. These trees are under fifty years of age. Little understory or ground cover has developed. All species found here are common in the woodlands of southern Maine. A list of these species is included in Appendix D.

Because of the predictability of the vegetation found on the site, an animal inventory was not undertaken. However, one could expect to find rodents and small birds and mammals characteristic of most disturbed areas and woodlands in the Northeast. No rare or endangered birds are known to nest here.

2.1.6 Aquatic Ecology

The lower Presumpscot River is characterized by a slow freshwater current, warm temperatures (up to 29°C in summer;

average 11.5°C: USGS 1978), and a substrate of mud, silt, or sand. Generally, the aquatic environment of the lower Presumpscot is typical of warm-water streams (see Section 2.2.6), but the ecosystem is less diverse than most due to the added stress from upstream point-source effluent discharge, surrounding development, and changing water levels.

The dominant phytoplankton are blue-green algae, although green and brown algae, euglenoids, and fire algae are also common. Surface-dwelling organisms include whirligig beetles and water striders. Zooplankton are principally copepods, cladocerans, coelenterates, rotifers, and ostracods. Vascular plants occur along the stream edge, and include emergents such as cattails and bullrushes, rooted plants with floating leaves such as water lilies, and submergent vegetation such as pond weeds. Insect larvae (especially midge, caddisfly, and mayfly) are usually the predominant bottom-dwelling invertebrates, but many species of flatworms, roundworms, freshwater sponges and shrimp, crayfish, leeches, mites, snails, and clams may be present. Fish species include carp, suckers, bullheads, and limited numbers of panfish (e.g., perch and bass). Frogs, toads, salamanders, and newts inhabit the weedy areas at the stream edge (Maitland 1978). Although some freshwater birds and possibly some aquatic mammals (especially muskrat) may inhabit the area, their numbers are small due to human disturbances (Hutchinson & Spencer 1975).

The only species protected by the Endangered Species Act of 1973 that could inhabit the Presumpscot River is the short-nosed sturgeon (Acipenser brevirostrum), which may have once inhabited most estuaries of the northeastern United States and eastern Canada. The short-nosed sturgeon is not now found in the Presumpscot (Squiers 1979) and the presence of dams downstream of the proposed plant site will prevent its return. No rare or endangered species are known to be present in the Presumpscot (Squiers 1979).

2.1.7 Land Use

Greater Portland Metropolitan Area

For the purposes of this discussion, Greater Portland will be said to include the communities of Cape Elizabeth, Cumberland, Gorham, Falmouth, Portland, Scarborough, South Portland, Westbrook, Windham, and Yarmouth. Together they cover 174,930 acres (PACTS 1977).

Greater Portland is not an intensively developed region; 66 percent of its total land area lies vacant. South Portland and Portland are the most developed municipalities, with 54 percent and 58 percent of their respective land areas utilized (PACTS 1977). The region's commercial activity centers in Portland and South Portland. Although small urban centers, highway strip development, and suburban shopping malls have sprung up in the outlying communities, Portland and South Portland together claim 65 percent of the region's commercial land area (PACTS 1977). The shipping industry, service facilities, cultural resources, and specialty retail outlets dominate the commercial acreage.

The Greater Portland area's industrial land is concentrated in Westbrook, Portland, and South Portland. Historically, industries located adjacent to hydropower sources or close to Portland Harbor, a phenomenon which explains why these three municipalities contain 93 percent of the region's industrial land (PACTS 1977). Recently, however, land-extensive industrial parks have appeared around the urban core and near access points of major highways such as the Maine Turnpike, Interstate 95, and Interstate 295 (GPCOG 1977a).

Residential areas are distributed throughout Greater Portland and are the predominant form of development within each of the region's communities. Peripheral communities are characterized by higher percentages of vacant and agricultural lands and very little additional development (PACTS 1977). Because the demand for land has remained relatively low, farmland has been preserved within a few miles of the urban core. Each Greater Portland

municipality, except Portland and South Portland, has over one thousand acres of agricultural land (PACTS 1977).

Power generation is a small but significant land use within Greater Portland. Five of the generating stations within Maine that feed into the Central Maine Power Company grid are located in the area. They are: the North Gorham hydro station (75.5 acres), the Wyman steam plant (100.2 acres), the Peaks Island internal combustion plant (1.9 acres), and the Cape steam and internal combustion plants (5.5 acres) (CMP 1977). Combined generating facility land area is 183.1 acres (Mathews 1978c).

Westbrook

The municipality of Westbrook, containing 10,911 acres, is one of the smaller communities of Greater Portland (PACTS 1977). In a central position within the metropolitan region, it forms a transition zone between urban core and rural periphery. As such, it includes a wide range of land-use types.

In terms of industrial land acreage, Westbrook leads Greater Portland with a total of 256 acres, most of which are located in the central and southern portions of the municipality (PACTS 1977). The S. D. Warren mill is the city's largest industrial facility, covering 182 acres on both banks of the Presumpscot River (Libby 1978a) just north of the downtown commercial district. Lining the Presumpscot in downtown Westbrook are older textile mills and machine shops; most of these buildings are now used as warehouses. Wood-based industries, manufacturing such products as plywood and dowels, and a gravel quarry are located in the eastern Larrabee Road Westbrook Arterial area. In the south between Saco and Spring Streets, site of the new Five Star Industrial Park, are found computer and tire manufacturers (Libby 1978b).

The commercial center of Westbrook is Main Street between Stroudwater Street and the Wayside Drive intersection, on the Presumpscot's southern bank, approximately one mile upstream of S.D. Warren. A commercial urban renewal project is near completion here. Commercial highway strip development has occurred in

sections of the city, most notably along Brighton Avenue, Warren Avenue, and Bridgton Road (Eyerman 1978).

Westbrook is characterized by a mix of residential types, occupying a total area of 1,126 acres (PACTS 1977). Multifamily and dense single-family neighborhoods are concentrated in downtown Westbrook, surrounding the commercial center. Middle- and low-density single-family acreages encircle this core, bordering directly on the S.D. Warren property's eastern, northern, and western boundaries (GPCOG 1975). Residential development is also interspersed throughout the northern and southern portions of the municipality. Agricultural lands are found in the extreme southern and northcentral sections of Westbrook, where development is limited and open space predominates. Table 2.1.7-A and Figure 2.1.7-B displays Westbrook's 1977 land use.

Within Westbrook, the Central Maine Power Company's transmission lines and substations occupy an area totaling 475 acres (Mathews 1978a). A right-of-way of four 115-kv lines intersects the municipality's southwest corner, and numerous 34.5-kv lines branch out from these to carry power to seven substations. A separate substation, fed by two 34.5-kv lines, serves the S.D. Warren mill site (CMP 1978).

2.1.8 Socioeconomic Profile

Description

Westbrook lies within the U.S. Department of Commerce's standard metropolitan statistical area (SMSA) of Portland, Maine. The Portland SMSA also includes Cape Elizabeth, Cumberland, Falmouth, Freeport, Gorham, Old Orchard Beach, Portland, Saco, Scarborough, South Portland, and Yarmouth. The SMSA encompasses 360 square miles.

Population Distribution and Growth Trends

In 1977 it was estimated that Westbrook had 14,590 inhabitants (MSPO 1977), Portland had 59,857, and the entire SMSA had 183,453 (GPCOG 1977a). Between 1950 and 1970, net outmigration offset births within the SMSA, so that total population growth was only 8.4 percent over that period, far below the national

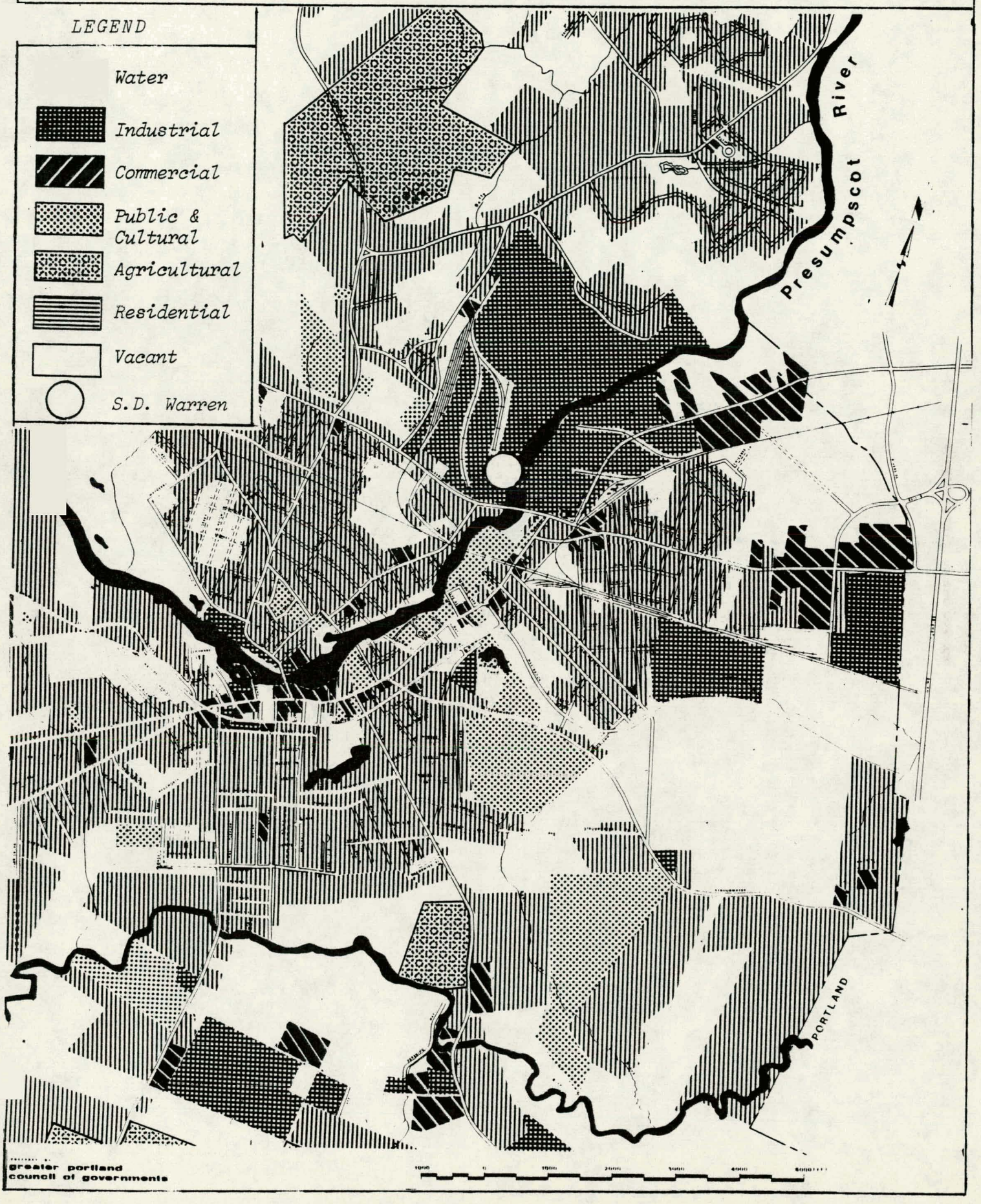
TABLE 2.1.7-A: WESTBROOK LAND USE - 1977

LAND USE CATEGORY	ACRES
Single Family Residential	912
Multi-Family Residential	214
Industrial	256
Trades	74
Services	129
Public Recreation and Open Space	167
Streets and Highways	517
Utilities and Rights-of-Way	711
Resource Extraction[1]	1,163
Other	7
Total Developed and Used Land	4,150
Developable Vacant Land	6,761
Undevelopable Vacant Land	0
TOTAL LAND	10,911

1. Includes primarily agricultural lands and gravel pits.

Source: PACTS 1977.

FIGURE 2.1.7-B LAND USE IN WESTBROOK AREA NEAR PROPOSED PLANT



average of 34 percent (Census 1960, 1970). (See Table 2.1.8-A.) From 1970 to 1975, the SMSA grew 7.8 percent, somewhat above the national average of 5.3 percent for that time period (GPCOG 1977a). This population increase was due mostly to inmigration.

Housing

Recent population growth has produced a housing scarcity; in 1970, 6 percent of the Portland area housing units were vacant. In 1976 the corresponding rate was 2.3 percent, with only 1.1 percent vacant in Westbrook. The region's substantial tourist industry increases the problem through temporary surges in population every July and August.

Income and Employment

Income. Westbrook, Portland, and South Portland have the lowest income in the SMSA, while Windham and Falmouth have the highest. In 1975 Westbrook had a median family income of $9,434 (Eyerman 1978).

Employment. The total civilian labor force in the Portland SMSA in June, 1978, was 83,300. The sources of employment have shifted from Portland to the suburbs and have changed in composition. In 1977, wholesale and retail trade and services accounted for 53.5 percent of total employment. The service sector was the single largest source of employment in the area and accounted for 28.1 percent of all employment. The percentage employed in construction increased from 6.6 to 7.3 between 1970 and 1977 (MDMA 1978a). Figure 2.1.8-A summarizes 1970 and 1977 employment in Greater Portland.

Unemployment. The unemployment rate for the SMSA has varied between 4.1 percent and 10.2 percent over the past decade. Average unemployment in 1978 was 4,100 persons, or 4.9 percent of the total labor force (Donahue 1979). Insured unemployed construction workers numbered 698 in Cumberland County in February of 1977. Of those, 20.2 percent were permanently laid off; the remainder were temporarily idle due to normal seasonality of the trade (MDMA 1978a). During the summer of 1978, about 550 insured construction workers were idle (Donahue 1978).

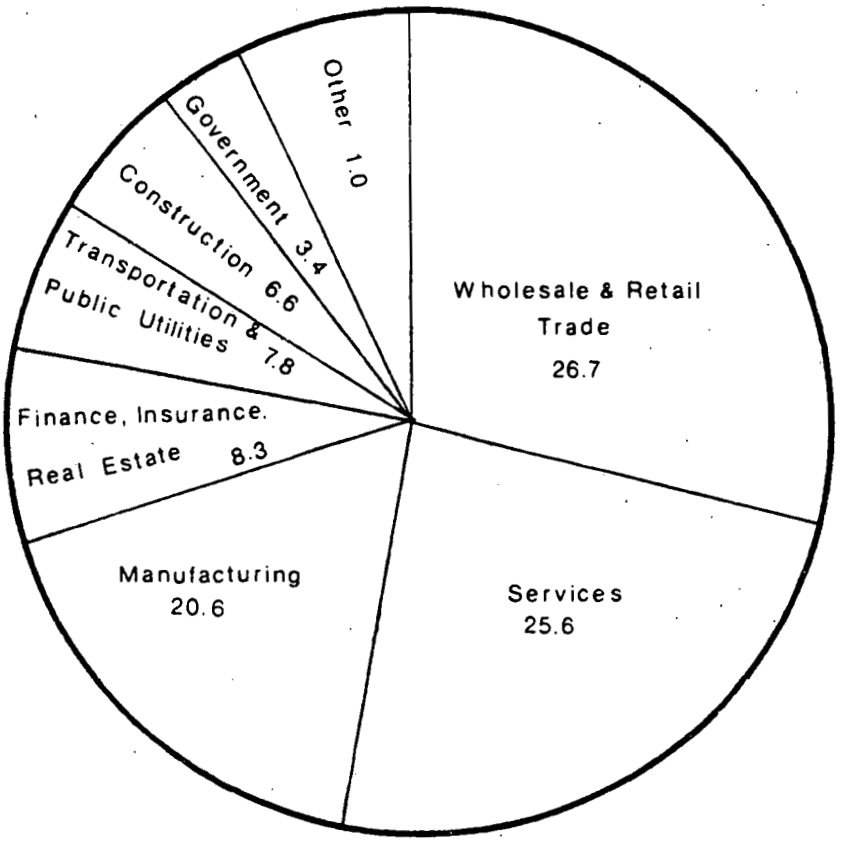
TABLE 2.1.8-A: CHANGES IN POPULATION FOR GREATER PORTLAND AND WESTBROOK FROM 1950 TO 1975

Population	Greater Portland	Westbrook
1950	155,728	12,284
1960	161,700	13,820
1970	170,081	14,444
1975	183,453	14,722
% Change in Population		
1950-1960	4.0%	12.5%
1960-1970	4.0%	4.5%
1970-1975	7.8%	1.9%
Net Migration		
1950-1960	-10,930	-154
1960-1970	-6,715	-833
1970-1975	+9,203	-298

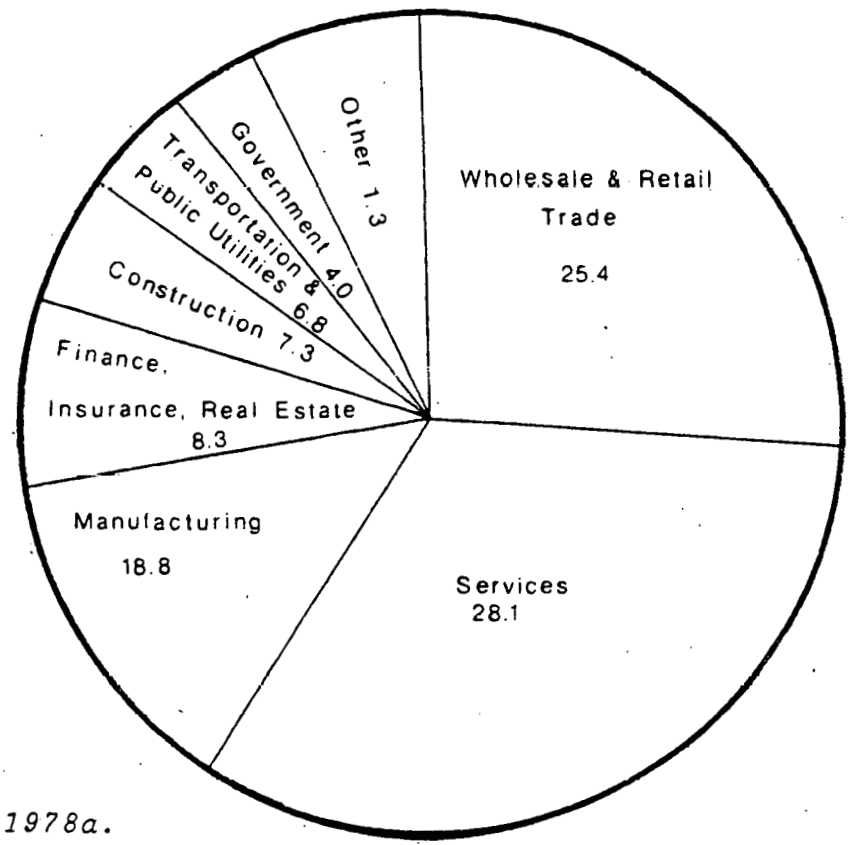
Source: GPCOG 1977a.

FIGURE 2.1.8-A: INDUSTRIAL EMPLOYMENT IN THE PORTLAND STANDARD METROPOLITAN STATISTICAL AREA

1970



1977



Source: MDMA 1978a.

Education

In the 1975-76 school year, there were 39,288 total students enrolled in Portland SMSA schools (GPCOG 1977a) and 1,821 total students enrolled in Westbrook schools (MDECS 1977a). Westbrook, like most towns in the region, has a student-teacher ratio well below the state average (14:1 versus 18:1) (GPCOG 1977a). Most area schools are currently underenrolled because of declining birthrates.

Westbrook had a 1976-77 per-pupil operating cost of $1,223. The 1977 school budget was $4,931,927 (Westbrook 1977), 61 percent of which came from property tax revenues. The rest of the school budget was provided by a state education subsidy of $517 per pupil in Westbrook.

Public Safety, Community Services, and Government Operations

A combination volunteer and paid firefighting staff and a police force of twenty-seven policemen provide adequate fire and police protection for the area. A private contractor collects the town's garbage. Rubbish is collected by the town and placed in the Westbrook sanitary landfill, estimated to have capacity for twelve more years of use. S. D. Warren also has its own landfill.

The 1977 budget for the city of Westbrook was $9,085,201, up 5.6 percent from 1976. Of the 1977 budget, $4,013,882 went to municipal expenses, $9,931,917 to schools, and $139,392 to county expenses. Within municipal expenses, $226,050 went to street maintenance and construction (Westbrook 1977; Parks 1978).

More than half of the 1977 expenditures were financed by property taxes totaling $5,295,435. Fifty-three percent of all municipal expenditures and 61 percent of school funding came from property tax, as did all of county expenditures. The remaining municipal revenues came from a number of sources.

Crime

Crime has risen substantially in the SMSA and is about average for an urban area of its size (FBI 1976). The overall crime rate for the SMSA is 62.4 reported crimes per 1,000 persons; for Westbrook, it is 45.9 per 1,000, below average for a city of its size (GPCOG 1977a).

Health, Public Assistance, and Social Services

The several hospitals in the Greater Portland area together provide more than eight hundred beds and average about 75 percent occupancy. There are a large number of social service programs in the Greater Portland area which serve many different groups' needs.

Economic Base

Sectors of the economy. The Greater Portland area and Cumberland County encompass more than three hundred industrial firms. The three largest plants are S.D. Warren and Data General in Westbrook and the semicondutor manufacturing division of Fairchild Camera and Instrument Company in South Portland. Westbrook contains approximately thirty-five of the area's total three hundred retail establishments (Cleaves 1978). This represents an increase of 10 percent since 1972. Retailing generated $440,111,000 in taxable sales in the Greater Portland SMSA in 1977 (Cleaves 1978).

Services and other nonmanufacturing industries continue to grow with the population. The hospitals are the largest employers in the service industry. Approximately one-half of the government sector employment is in the area schools. Employment in this sector may soon experience a decrease due to declining enrollments. Contract construction declined because of the recession from 1973 to 1975. However, many new construction projects, including Portland's $65 million sewage treatment plant, are helping this sector's recovery (MDMA 1978a).

Manufacturing in the Portland area is recovering from the recession with greatest strength in nonelectrical machinery and fabricated metal products.

Taxes. Portland and South Portland have the highest property tax rates in the SMSA (see Appendix E). Westbrook has a tax rate of $26 per $1,000 at a 90 percent assessment ratio.

The sales tax in the state is 5 percent of all tangible personal property sold for use or consumption within the state (Cleaves 1978). State corporate income tax is 5 percent of the

first $25,000 of net income and 7 percent on all net income in excess of $25,000 (Cleaves 1978).

2.1.9 Historic, Cultural, and Aesthetic Resources

History

Westbrook has shared the historical development of the region (see Appendix I). The predecessors of the white settlers of Westbrook were the Aucocisco Indians, an Abenaki subtribe which inhabited the Presumpscot River region. The first white people to traverse the region were hunters and trappers from Massachusetts and New Hampshire, who came to hunt beaver. Although tracts of land along the banks of the Presumpscot River had been bought from the Aucociscos as early as 1666, the first permanent white settlers of the region did not arrive until 1739.

Westbrook became incorporated as a city in 1814, taking in the former towns of Saccarappa and Congin. These two settlements grew up one mile apart around the falls of Saccarappa and Ammoncongin, respectively. At these points dams were built, saw and grist mills constructed, and communities established (Rowe 1952).

Thus the Presumpscot's hydropower resources were a most significant factor in Westbrook's growth. By the mid nineteenth century, textiles and wood products industries had sprung up along the river (Rowe 1952) and included the Congin Paper Mill at Ammoncongin Falls. This mill, built in 1845, utilized the river's water in industrial processes and for steam generation and had the additional advantage of being located close to Portland Harbor, an important source of rags, then the principal pulp ingredient (S.D. Warren 1973). In 1854 Samuel Dennis Warren of Boston bought the Congin Paper Mill and was responsible for its expansion in the next decades. In 1880 the S.D. Warren Company built a pulp mill which used a new chemical wood-pulping method and poplar from the Sebago Lake region to the northwest (S.D. Warren 1973).

In the present century, Portland and Westbrook have merged at the latter's eastern boundary. Westbrook industrial expansion

in recent years--in wood products, electronics, and tire manufacturing--has occurred on the periphery of the urban center. Suburbanization of Greater Portland has caused some residential and commercial growth in outlying portions of the city.

Archaeologic Sites

Many of the metropolitan region's archaeologic sites, both known and potential, have been lost to development (see Appendix I). Within the city of Westbrook, the possiblility of discovery and preservation of prehistoric sites has been largely eliminated by industrial, commercial, and residential construction along the Presumpscot and Stroudwater Rivers. This is true of the S.D. Warren property. As highly industrialized land that has been continually compacted and built on for over a century, the site is of no archaeological value (Shettleworth 1978).

Historic Sites

Westbrook has historic structures representing three centuries of American development. The one Westbrook site that is most relevant to this project is the Cumberland Mills Historic District, a federally recognized historic landmark. This district, covering both sides of the Presumpscot River between the railroad tracks and Warren Avenue, was a planned industrial community of the nineteenth century. It includes the original paper mill complex, commercial and public buildings, and workers' housing (NPS 1976).

Notable district structures include the Cottage Place workers' cottages (1886), the William L. Longley House or "The Elms" (1882), the John E. Warren House (1882), and the The Warren Block (1883). These structures were designed by the Portland architect John Calvin Stevens and are of the Queen Anne style (S. D. Warren 1975).

Aesthetic Resources

While the eastern portion of Westbrook is largely commercial and industrial, most of the rest of the municipality is undeveloped forest and farm land and has retained its natural beauty. The Presumpscot and Stroudwater Rivers contribute to the countryside's visual quality. Central Westbrook itself, with its numer-

ous historic structures and recently rehabilitated downtown district, is visually pleasant. The Presumpscot River is the central city's major aesthetic asset, as the river's waters appear clean and undisturbed from its heavily vegetated edges.

The S.D. Warren Company mill, a 182-acre industrial complex, (Libby 1978a), is a major feature of Westbrook's landscape. When viewed from the immediate west, the mill occupies one's entire scope of vision, as it does when one approaches the city from Portland and South Main Street (see Figure 2.1.9-A). However, while Main Street and Park Street are both relatively well-traveled routes, the S.D. Warren plant, with the exception of its stack, cannot be seen from most points in the city. From downtown Westbrook, the view of the mill to the north is obstructed by vegetation, as it is from Deer Hill, a residential district and one of the highest points within municipal boundaries (see Figure 2.1.9-B). Thus, the mill's major visible feature is its stack, which can be seen from many points within Greater Portland.

Noise

The area surrounding the proposed plant site is characterized by high levels of noise, of which the S.D. Warren mill is the primary source. Between 1971 and 1974, S.D. Warren monitored ambient, or background noise at six test stations around the mill complex (see Figure 2.1.9-C). On a given test day, sound pressure level readings in decibels were taken at each station at approximately 10 a.m., 2 p.m., and 10 p.m. on the A, B, and C scales of a standard sound pressure level meter (Johnson 1974). Only the A-weighted sound levels (dBA) have been used in this study, as the frequency response of the A scale most closely resembles the human ear's perception of sound (Bragdon 1970). The 24-hour equivalent sound levels for each station are summarized in Table 2.1.9-A (see Appendix H for the derivations of these figures and a complete explanation of the noise analysis).

Test stations #1, #2, and #6 are the sites of the highest recorded sound pressure levels. These stations are also located closest to the mill and are surrounded by the least sensitive land uses: commercial, industrial, and high-density residential

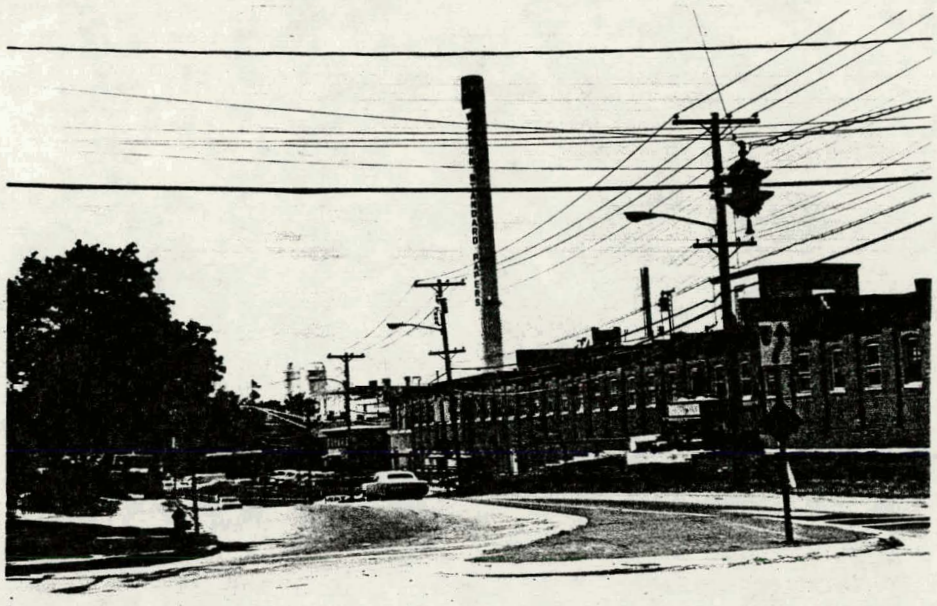


FIGURE 2.1.9-A: VIEW OF S.D. WARREN MILL FROM INTERSECTION OF CUMBERLAND STREET AND WARREN AVENUE TO THE EAST

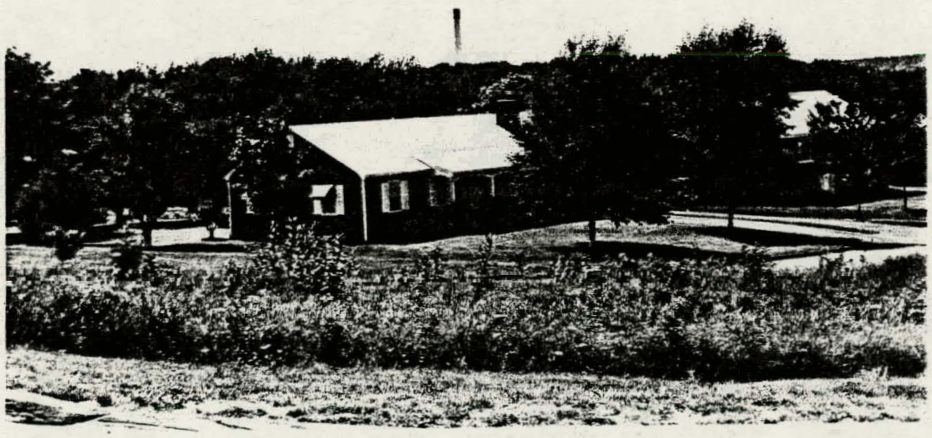


FIGURE 2.1.9-B: VIEW OF S.D. WARREN SMOKESTACK FROM DEER HILL LOOKING SOUTHWEST

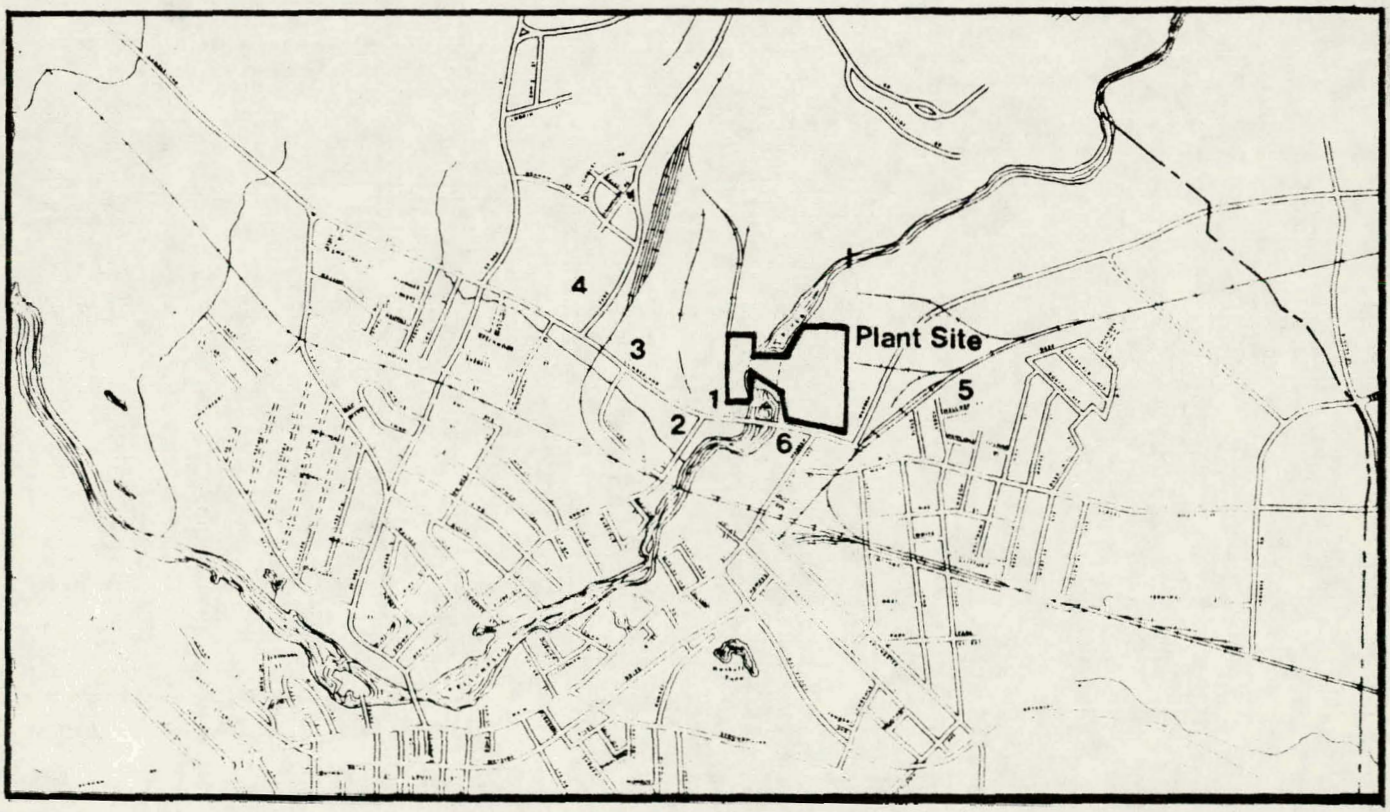
TABLE 2.1.9-A: AMBIENT NOISE LEVELS AT SIX S.D. WARREN TEST STATIONS

(dBA)[1]

Test Station	Average Annual Sound Level[2]	Average Annual Sound Level - Penalty Applied[3]
#1 Cumberland St. & S.D. Warren Gatehouse	65	71
#2 Cumberland St. & Brown St.	65	71
#3 Cumberland St. & Cottage St.	53	58
#4 Westbrook Community Hospital (Park Rd.)	54	60
#5 Lower Forest St. - End	47	52
#6 Cumberland St. & Warren Ave.	62	67

1. dBA = decibels on A-weighted scale.
2. Annual average of $L_{eq}(24)$, or equivalent sound level over 24 hours.
3. Annual average of L_{dn}, or equivalent sound level over 24 hours with 10-decibel penalty applied 10 p.m. - 7 a.m.
Source: Johnson 1974.

FIGURE 2.1.9-C: LOCATION OF THE SIX NOISE TEST STATIONS



(see Section 4.1.3). At Station #4, the Westbrook Community Hospital, the sound levels are slightly higher than those at Station #3. Station #5 is located furthest from the mill in a residential area and has the lowest recorded ambient noise.

In studying Table 2.1.9-A, one must note that decibels are dimensionless, logarithmic units of sound pressure. An arithmetic decrease in decibel level represents a geometric decrease in sound pressure level. For example, the average annual sound level of Station #6 is actually about two-thirds that at Station #2. Thus, while ambient noise level is high immediately adjacent to the mill, the level rapidly decreases as one moves away from the mill.

2.1.10 Transportation Systems

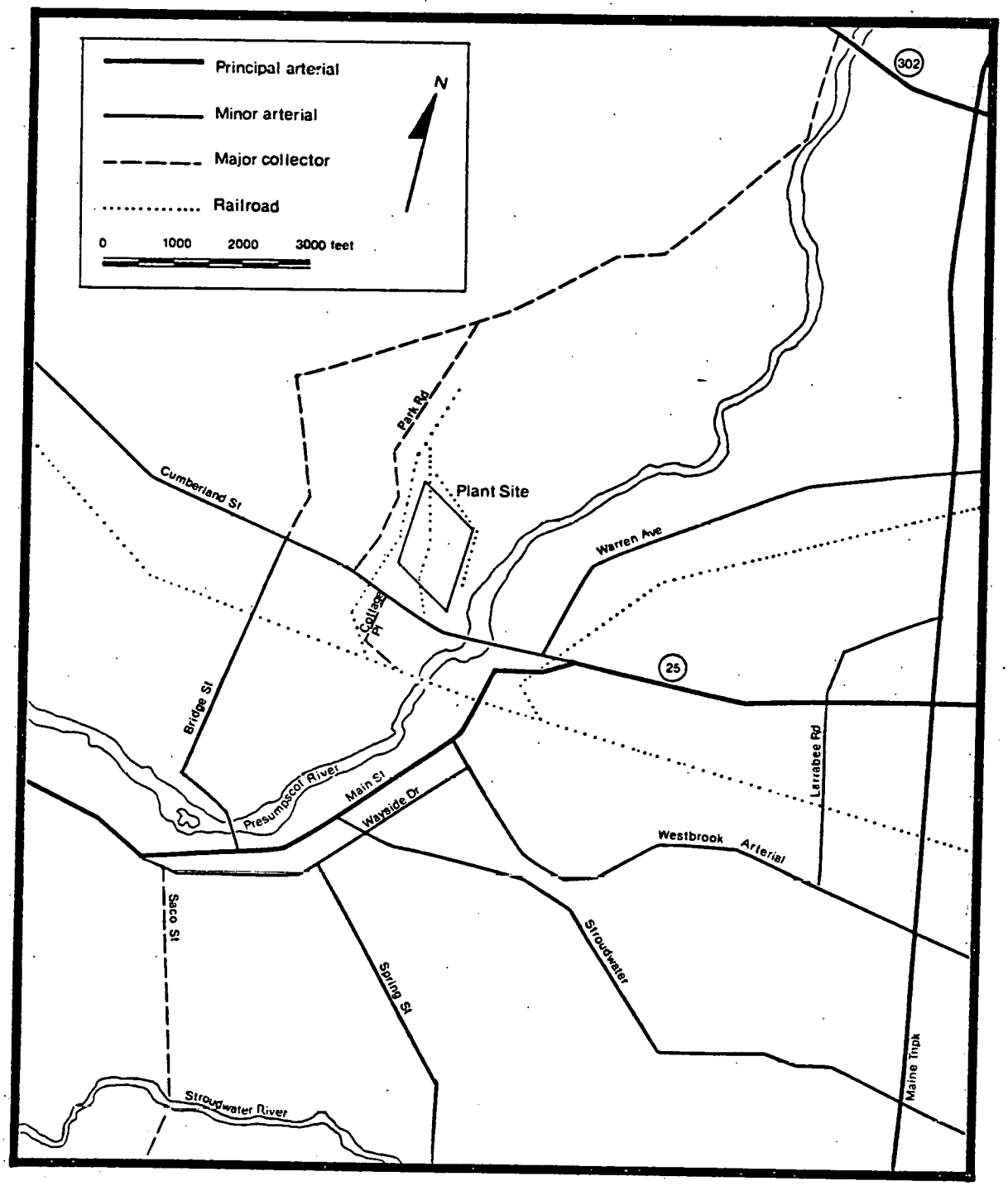
Roads

The two principal roads serving the city of Westbrook, Maine, are U.S. Route 302 and Maine Route 25. U.S. Route 302 serves only the northern sector of the city, while Route 25 runs through the center of town, where it becomes Main Street. Both routes intersect the Maine Turnpike in Portland.

Roads with heaviest traffic flow in Westbrook are delineated in Figure 2.1.10-A. The Westbrook Arterial and Wayside Drive relieve traffic flow on Main Street, allowing vehicles to bypass the central business district and the Cumberland Mills area. All road surfaces are in good condition and most have grades less than 3 percent (Reidman 1978). Speed limits range from 25 to 35 miles per hour. Eleven traffic signals operate in the city; the Maine Department of Transportation is currently studying placement and timing of traffic signals in Westbrook and the results of the study may lead to some changes in the current system (Thomas 1978b).

Turning movement studies (i.e., traffic counts made at intersections) and vehicle classification counts made in November of 1977 (determining the relative frequency of different vehicle types at intersections) indicated that trucks comprised approxi-

FIGURE 2.1.10-A: MAJOR ROADS IN WESTBROOK



mately 5 percent of total peak-hour traffic in the city (Thomas 1978a).

The most serious traffic flow problems associated with truck movement normally occur at the traffic triangle at the intersection of Maine and Cumberland Streets, where traffic moves one way in a counterclockwise direction. Trucks have difficulty negotiating the turn from Main Street and often block two lanes of traffic along Cumberland Street in so doing. This impedes westbound traffic, occasionally causing congestion near the mill area (Reidman 1978).

Rail

The Maine Central Railroad serves Westbrook in conjunction with the Portland Terminal Company. Trains arrive four times daily, two to switch cars near Warren Avenue on the east side of the Presumpscot River and two to load and unload at S.D. Warren Company's private sidings to the west of the river near Park Road (Corvetti 1978). Tracks run through the central business district parallel to Main and Cumberland Streets (see Figure 2.1.10-A). Railcars approach the site on an overpass crossing above Cumberland Street near the intersection of Cumberland Street and Park Road.

Bridges

There are two railroad overpasses and five bridges in the Westbrook area used by railcars and trucks serving the S.D. Warren plant. The railroad overpasses are located near the intersections of Cumberland Street and Park Road, and Brown Street and Cottage Place. They both have clearance heights of 11'1", too low to allow most heavy trucks to pass underneath. Brown Street is too narrow for use by heavy trucks, so only the overpass at Cumberland Street and Park Road poses a problem for truck access to the mill area. Due to the location of this overpass, trucks approaching S.D. Warren from the west must be rerouted to approach from the east along Cumberland Street.

Bridges are located across the Presumpscot River along Cumberland Street, Bridge Street, and U.S. Route 302. Bridges cross the Stroudwater River on Spring and Saco Streets. Notice-

able and recurring congestion occurs only on the Cumberland Street Bridge and then only at certain hours. This bridge experiences congestion around 7:00 a.m. and between 3:00 and 4:00 p.m. These are the hours at which S.D. Warren employees arrive at, or leave, the mill area. Once the mill workers leave the Cumberland Street bridge area, congestion eases (Stearns 1978).

Service to S.D. Warren

S.D. Warren Company currently receives approximately 350 truckloads per month of raw materials and supplies and 1,700 truckloads per month of roundwood and wood chips. In addition the plant receives an average of 125 railroad boxcars per month of materials and supplies. Around 750 truckloads and 106 railroad boxcars of miscellaneous materials and finished products leave the plant each month (Crawford 1978).

Trucks arrive at the plant site to load and unload between the hours of 5:00 a.m. and 10:00 p.m. Monday through Friday and from 6:00 a.m. to 12:00 p.m. on Saturday. Trains arrive at the plant between 8:30 a.m. and 1:00 p.m. Monday through Saturday (Crawford & Orach 1978). Special compactor trucks transport sixty tons a day of waste from the plant to a landfill on the Scarborough-Westbrook line via Main Street, Spring Street, and Route 22 south. This landfill, if also used for wood ash disposal, may be filled in one and one-half years at which point another landfill site will have to be found (Labrecque 1979).

Local Reactions

According to the city engineer and mayor of Westbrook, no serious transportation problem is perceived to exist currently in the city. Noise levels and air pollution caused by ground transportation are considered negligible. Traffic congestion seldom occurs, and then only during peak hours. The people of Westbrook have not complained of adverse impacts related to truck traffic in the area and seem content with the present system (Reidman et al. 1978).

2.2 PRESENT ENVIRONMENTAL SETTING OF FUELWOOD HARVEST REGION

2.2.1 Physiography

Topography

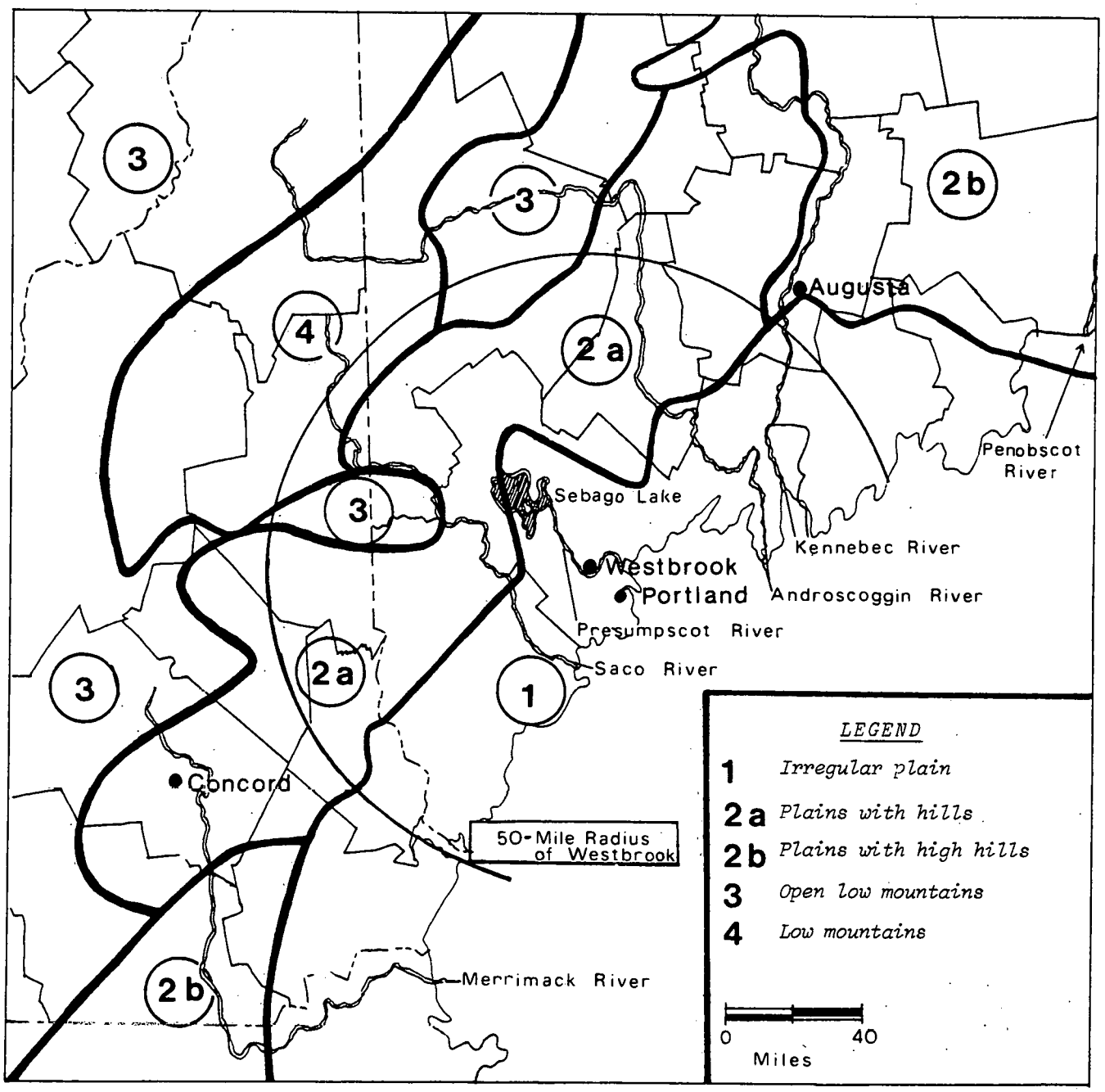
The land surface of the fuelwood harvest region can be divided into four distinct topographic subregions, each trending in a northeasterly direction. These regions increase progressively in elevation and relief away from the coast (see Figure 2.2.1-A).

The coastal subregion extends an average of about twenty miles inland, though it narrows in the north. It is primarily an undulating plain; much of it is 100 to 200 feet above sea level (Hammond 1964; Connor 1976). To the northwest of the coastal zone is a 20- to 25-mile wide belt of rolling hills (Connor 1976) with a local relief of 500 to 1,000 feet (Hammond 1964). In the northern and southern extremities of the belt the hills are relatively higher. Bordering the landward side of this belt of rolling hills is an area of increasing elevation and slope with steep hills and a local relief of 1,000 to 3,000 feet (Connor 1976). Finally, in the northwesternmost part of the fuelwood harvest region lie the White Mountains of east-central New Hampshire and southwestern Maine. Relief in this subregion is very pronounced, but not all of the land is steep. Substantial areas of relatively flat land occur as mountain bowls in several locations (Connor 1976). Overall, 95 percent of the total land area within a 50-mile radius from Westbrook has slopes of less than 15 percent.

Geology

Past glaciation has had a profound effect on both the topography and surface geology of the harvest region. The area is covered by an almost continuous blanket of glacial till (a relatively unstratified mixture of mineral material with individual particles ranging in size from fine clays to large boulders) (Goldthwait 1969).

FIGURE 2.2.1-A: TOPOGRAPHIC CHARACTERISTICS
OF THE FUELWOOD HARVEST REGION



Source: Hammond 1964

Previous incursions inland by the ocean have resulted in the deposition of an almost continuous layer of marine clays over Maine's coastal area. These clays also occur as discontinuous patches in New Hampshire (Goldthwait 1969). Also, there are broad areas within the harvest region where stratified deposits of sand, silt, clay, and gravel have accumulated due to both glacial outwash in the past and the stream action of relatively more recent times (Goldthwait 1950). Bedrock geology does not have significant implication for the wood-harvesting aspects of this project.

In 1977 sand and gravel were both Maine and New Hampshire's primary mineral products (Barton 1978). The widespread occurrence of these deposits is of particular importance to the timber industry since the availability of these materials simplifies the construction of logging roads.

Both Maine and New Hampshire have recently seen considerable prospecting activity. Over the past year, some thirty companies have investigated the White Mountains of New Hampshire in hopes of locating a substantial low-grade reserve of thorium and uranium (Lyons 1978). Other mining activities in the two states are minimal. Barring the possibility of widespread development of thorium and uranium mining, the extraction of minerals will continue to have only a local impact on the future production of wood within the harvest region.

Soils

With a few exceptions the soils of the harvest region are orthods that are freely drained and occur largely in coarse, acid deposits under forest vegetation where coniferous species tend to be predominant. Upper layers of these soils are readily leached, and organic matter, aluminum, and iron accumulate in a lower layer of the soil.

Soil drainage has an important effect on a region's entire ecological system. Rapidly drained soils may create drought-like conditions and may limit revegetation. In the harvest region the problem of poor drainage is more prevalent. High water tables result in waterlogged soils, preventing root aeration and pene-

TABLE 2.2.1-A: MAJOR SOILS OF COUNTIES COMPRISING THE FUELWOOD HARVEST REGION[1]

County & State	Predominant Soil Series	Taxonomic Group	% of Total County Soils
Belknap, NH	Gloucester	Haplorthod	35
	Shapleigh	"	20
	Paxton	Fragiorthod	14
Carroll, NH	Lyman	Haplorthod	8
Strafford, NH	Hollis	Haplorthod	26
	Gloucester	"	21
	Charlton	"	11
Androscoggin, ME	Charlton	"	18
	Hollis	"	15
	Adams	"	12
Cumberland, ME	Hermon	"	19
Kennebec, ME	Hollis	Haplorthod	20
	Paxton-Charlton	Haplorthod	16
	Woodbridge	Fragiorthod	14
Sagadahoc, ME	Hollis	"	39
	Buxton	Eutrochrept	14
York, ME	Brookfield	Haplorthod	13
	Gloucester	"	12

1. *The U.S. Soil Conservation Service has not yet surveyed Lincoln and Oxford Counties in Maine; therefore, we have no data for these counties.*

Sources: County Soil Surveys for Belknap (SCS 1968), Carroll (SCS 1977a), Strafford (SCS 1973), Androscoggin and Sagadahoc (SCS 1970), Cumberland (SCS 1974), Kennebec (SCS 1978) and York (SCS 1952).

tration. Although most of the soils of the area are moderately or well drained, two soil types (gleysols and histosols) that are normally poorly drained do occur in the area. Appendix D details the characteristics of the soils of the fuelwood harvest region.

Within the U.S. Soil Conservation Service soil surveys, each soil series is assessed for its effects on seedling mortality, plant competition, use of equipment, woodland roads, and windthrow hazard. Three soil types in the area show potential mortality of greater than 50 percent for tree seedlings. These are the Hollis, Lyman, and Adams soils. Soils where desirable trees are unable to regenerate without site preparation and maintenance are the Charlton, Buxton, and Paxton soils. Problems of windthrow are severe only in Brookfield soils. Almost all soils may severely limit the use of equipment and building of woodland roads, particularly in areas where slopes are steep, drainage is poor, or soil is wet for more than three months of the year. Indices of erosion show the predominant soils to have little erosion potential under forest cover and proper management (SCS 1977b).

2.2.2 Climate

The fuelwood harvest region lies in the coastal and southern interior climatic divisions of the state of Maine and the adjacent portions of central New Hampshire. Relative to other parts of the country, this portion of New England experiences a large number of storms each year. The interaction of dry, cold air masses from the Canadian subarctic and moist, warm air masses from the Gulf of Mexico produce a regional climate that is characterized by frequent change. These weather systems are further modified in coastal portions by cool, moist air masses from the North Atlantic. Climatic conditions from month to month and from year to year vary substantially. Additionally, the local effects of the ocean, elevation, and terrain cause significant variability in both temperature and precipitation from place to place.

The annual temperature for the entire region averages 44 to 45°F (NOAA 1977). In the interior, summer average temperatures approach 70°F, while they average about 64°F on the coast. Average winter temperatures approximate 20°F along the coast and 10°F inland.

Annual precipitation varies from 40 inches over inland portions to 45 inches in coastal regions (Lautzenheiser 1972). In general this precipitation occurs relatively evenly throughout the year, though portions of the area may experience exceptionally dry or wet periods. Periods of prolonged drought, however, occur only infrequently. Average annual snowfall ranges between 50 to 80 inches along the coast and 60 to 90 inches inland (Lautzenheiser 1972).

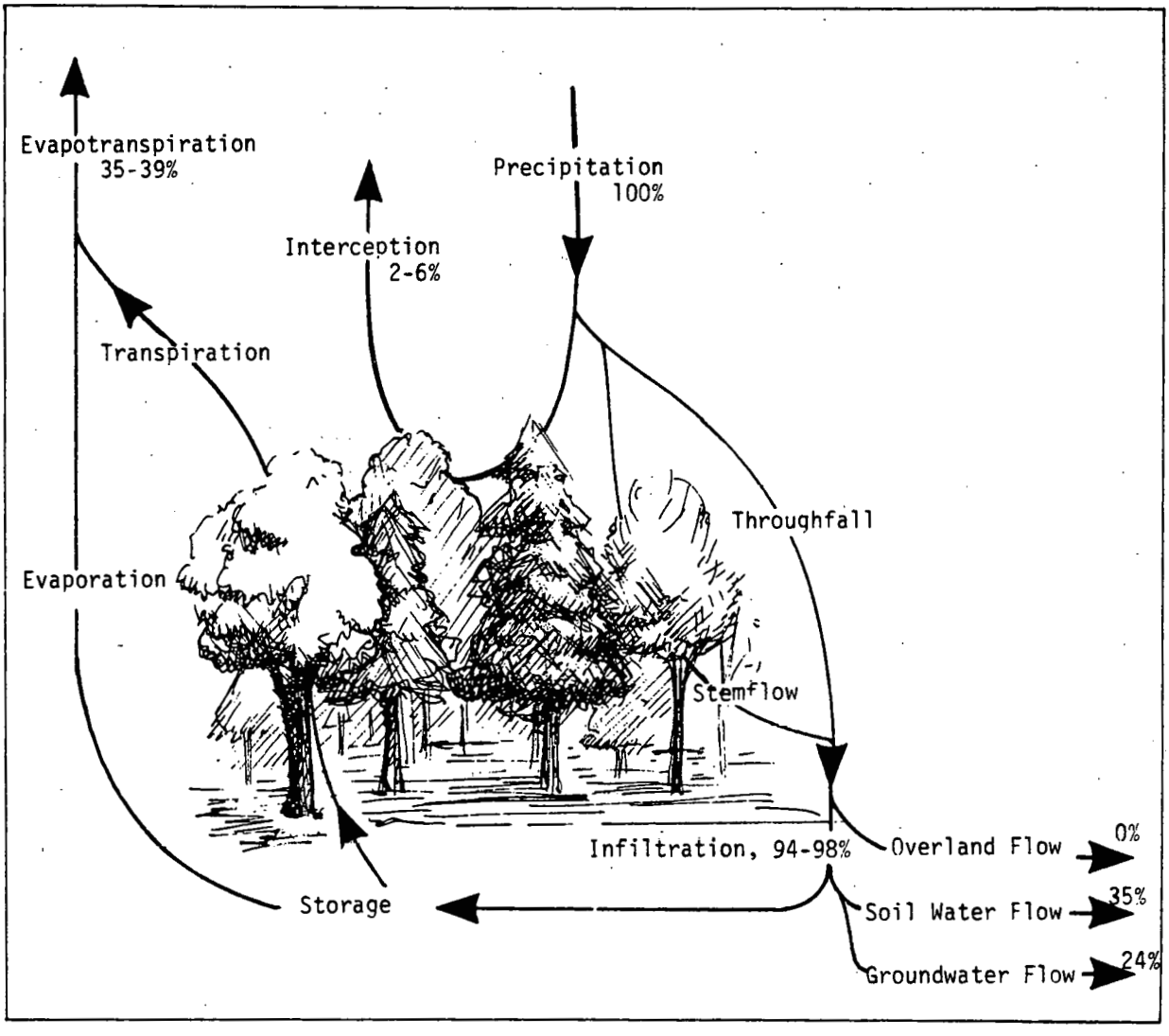
With a growing season ranging from 120 to 160 days (Lautzenheiser 1972) and precipitation evenly dispersed throughout the year, the climate is well suited to the production of forests. However, catastrophic events can cause major disturbances to forested ecosystems. Winds associated with hurricanes, occurring on average one out of every two years (Ludlum 1976), or the more frequent winter northeasters occasionally damage timber stands. Ice storms, common along the coast but less frequent inland, also damage timber stands at irregular intervals.

2.2.3 Hydrology and Water Resources

The Hydrologic Cycle

The hydrologic cycle within the forest of the harvest region follows the pathways shown in Figure 2.2.3-A. The major input of water to the cycle occurs as precipitation, which averages between 40 and 45 inches per year in the harvest region (see Figure 2.2.3-B). In the hardwood forests of the region, approximately 10 percent of this precipitation is caught up by the trees (intercepted) and evaporated back into the atmosphere without ever reaching the ground. Coniferous trees intercept a larger portion of precipitation (Wisler & Brater 1959; Gray 1973), sometimes as much as 25 percent of total annual precipitation in

FIGURE 2.2.3-A: HYDROLOGICAL CYCLE IN THE FUELWOOD HARVEST REGION[1]

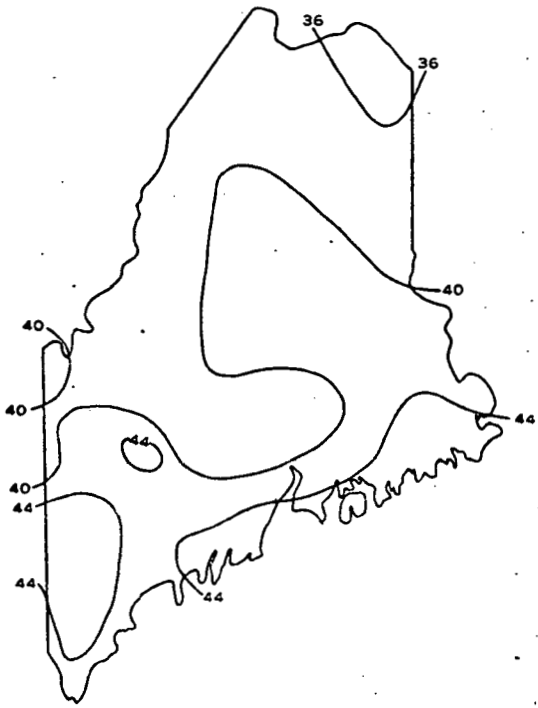


1. Percentages are of total annual precipitation.

Sources: Lull & Reinhart 1972; Likens et al. 1971; Prescott 1977.

FIGURE 2.2.3-B: HYDROLOGICAL DATA FOR MAINE AND NEW HAMPSHIRE

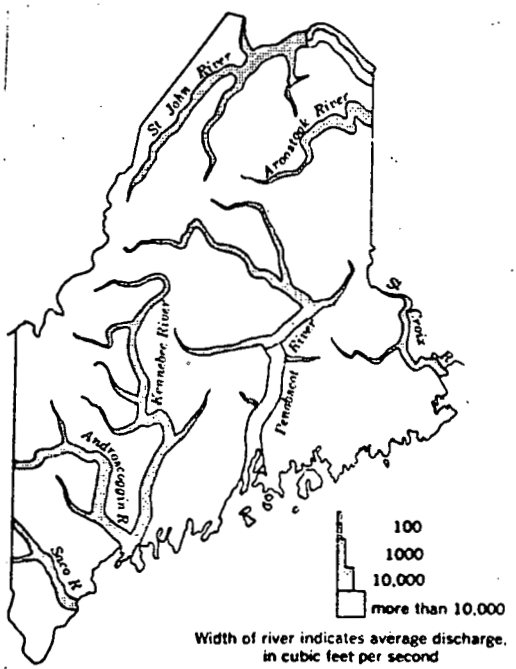
MAINE



MEAN ANNUAL PRECIPITATION, IN INCHES
(Data from U.S. Weather Bureau—ESSA)



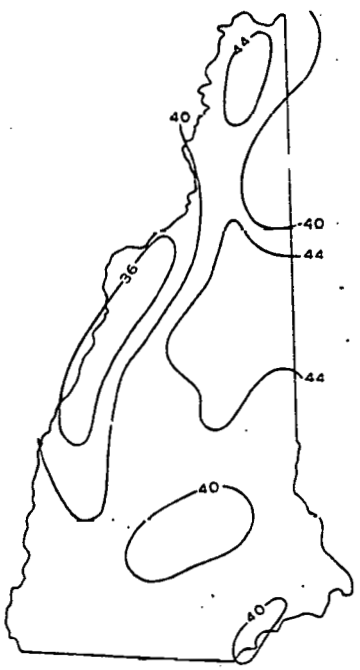
AVERAGE ANNUAL RUNOFF, IN INCHES



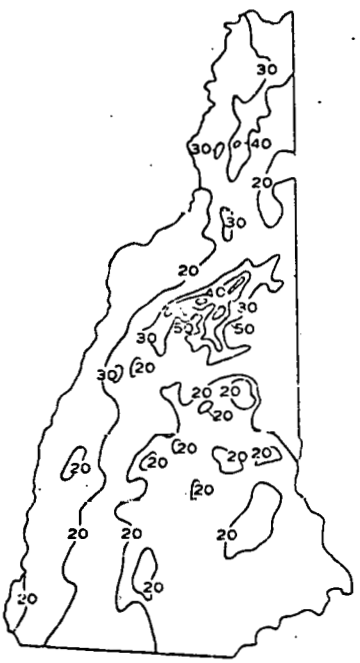
Width of river indicates average discharge, in cubic feet per second

AVERAGE DISCHARGE OF THE PRINCIPAL RIVERS

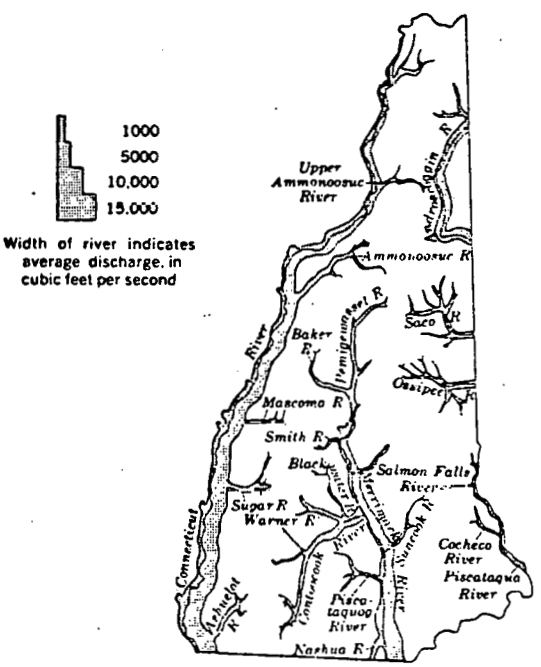
NEW HAMPSHIRE



MEAN ANNUAL PRECIPITATION, IN INCHES
(Data from U.S. Weather Bureau—ESSA)



AVERAGE ANNUAL RUNOFF, IN INCHES



Width of river indicates average discharge, in cubic feet per second

AVERAGE DISCHARGE OF THE PRINCIPAL RIVERS

Source: USGS 1968.

dense forests. Both forest types intercept higher portions of snow than rain, causing winter moisture losses to be greater than those of other seasons and significantly reducing springtime freshet flows.

Nonetheless, by far the largest portion of precipitation reaches the ground surface either directly as throughfall or indirectly as stemflow (see Figure 2.2.3-A). The precipitation subsequently either filters into the ground, collects in surface depressions, or runs off across the ground surface. The rate and ultimate percentage of precipitation that infiltrates into the soil depends on the level of soil moisture when precipitation begins and also on the texture and structure of the soil. Low soil moisture allows rapid rates of infiltration (between ten and one hundred millimeters per hour, according to Miller 1977); these rates usually exceed rainfall intensity (Armson 1977). As the soil gets wetter, however, the rate of infiltration rapidly decreases.

Within the fuelwood harvesting region, approximately half of the annual precipitation returns to the atmosphere through evaporation and transpiration (evapotransporation) and evaporation following interception (Prescott 1977). Climatic conditions, type of vegetation, and soil cover all affect evapotranspiration. The presence of a forest canopy greatly reduces evaporation directly from the soil surface as it lowers exposure of the soil to sunlight and air movement, although transpiration by the vegetation more than compensates for this reduction.

Surface flow, soil water flow, ground water flow, and snowmelt all contribute to surface runoff in streams and rivers. Overland flow occurs only rarely in the forests of this area during very heavy rainstorms when the precipitation rate exceeds the infiltration capacity of the soil. Soil water and ground water flow comprise the major portion of the runoff in this portion of New England, although snowmelt is of importance during the spring melt period (Hayes 1966).

Annual runoff and ground water levels follow similar patterns. Both are low towards the end of the summer growing sea-

son, but they rise again with autumnal rains and lowered evaporated rates through the beginning of winter. Snow and frozen soils temporarily store potential runoff and ground water on the surface, so winter levels consequently drop. Peak runoff and ground water levels occur during the March to April snowmelt period.

Ground Water Resources

The quality of ground water is generally good through the region; mineralization of the water is highly variable, depending on the medium through which it flows. Localized incidences of chloride, nitrate, or very hard water have resulted from seepage from fertilized fields, septic tanks, feedlots, salted roadways, or salt water. In addition, some aquifers have high iron concentrations (Prescott 1969).

River Resources

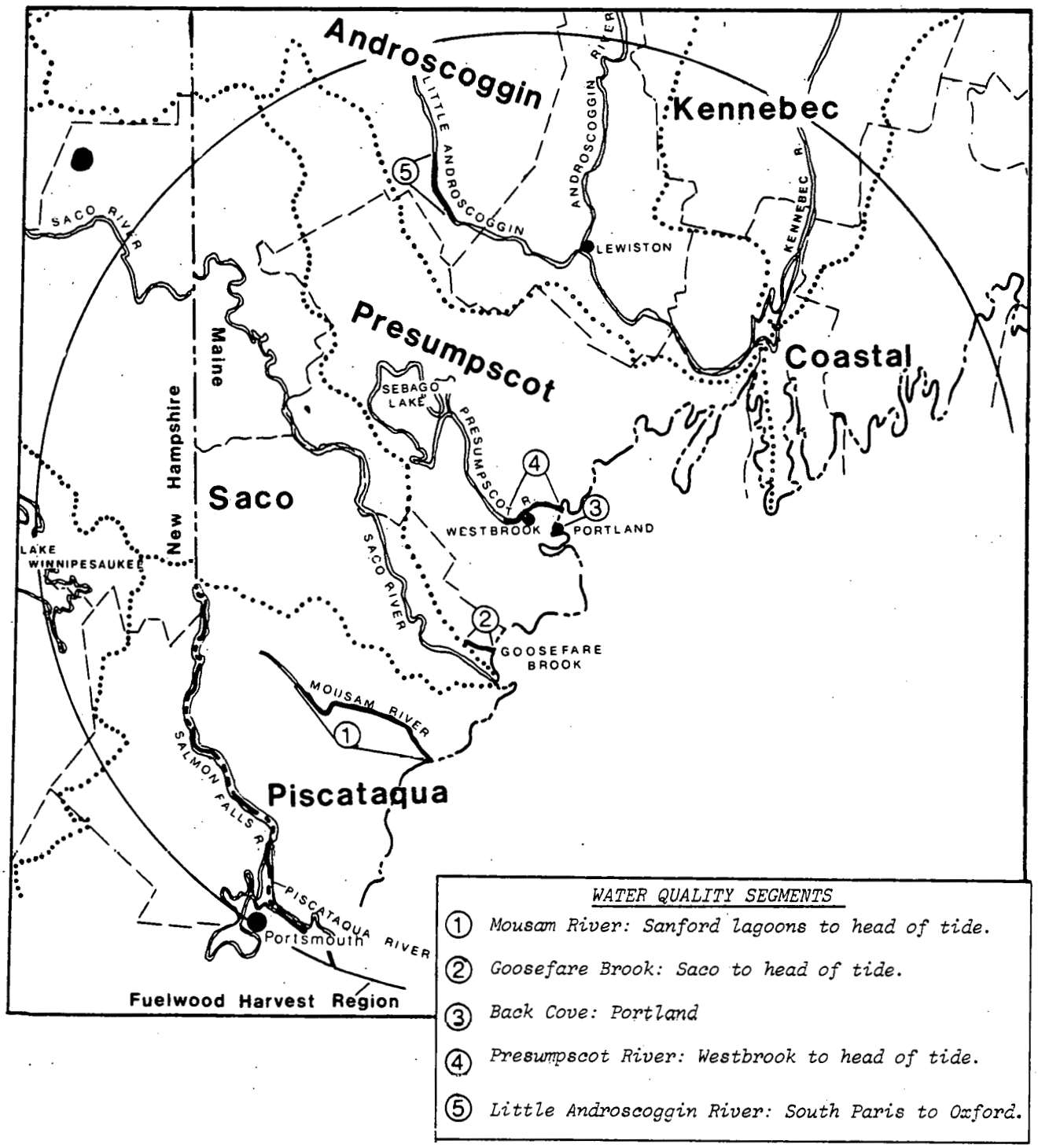
The harvest region encompasses parts of six major hydrological basins. These basins are depicted in Figure 2.2.3-C. Average rates of discharge for the principal rivers are shown in Figure 2.2.3-B.

Although differing in dimensions, the various river basins share several characteristics. All the rivers originate from clean upland streams. The most significant degradation of water quality usually originates where the rivers pass through populated and industrial areas of cities that had originally located along the rivers for hydropower and transportation.

Major water quality problems have been associated with discharges of raw domestic wastes and industrial effluents, particularly from paper and pulp mills. The particular water quality problem will vary depending on the source of effluent. High levels of bacterial contamination, low levels of dissolved oxygen, and suspended and deposited sediments are characteristic of untreated municipal wastes. Paper and pulp mills have in the past discharged raw effluent with high oxygen demand and high total solids concentrations.

On a regional level, the abatement of nonpoint sources of pollution is considered less important than the control of point

FIGURE 2.2.3-C: MAJOR RIVER BASINS IN THE FUELWOOD HARVEST REGION



Sources: USGS 1974a; MBWQC-K 1976; MBWQC-A 1975; MBWQC-MC 1976; MBWQC-P 1976; MBWQC-SM 1976; USGS 1974b. NHWSPCC-S 1975; NHWSPCC-P 1975.

sources for the improvement of water quality. Nonpoint pollution stems from silviculture, agriculture, construction, urban and suburban runoff, subsurface waste disposal and road de-icing. Presently, the effects of these sources are largely masked by the degradation evolving from point sources.

Eutrophication of lakes is a major nonpoint-source problem throughout the region. This degradation largely evolves from agricultural and developed land runoff and subsurface disposal of wastes. Isolated cases of accelerated silting such as at Zircon Brook and Varum Pond in the lower Androscoggin Basin are commonly held to result from poor management of timber operations (Thompson 1978). Problems of silting and nutrient loading from timber activity arise largely where management plans are not followed.

Water Supply Systems

Within the biomass harvest region both surface and groundwaters are used for municipal supply systems. Treatment of supply waters varies from none in many smaller systems to combinations of filtration, sedimentation, disinfection, coagulation, contact beds, chlorination, and fluoridation in the larger systems (NHWSPCC 1977; MDHS 1972-1978).

2.2.4 Ambient Air Quality

The fuelwood harvest region includes all of National Air Quality Control Region 110 and parts of Regions 107 (Maine) and 107, 149, and 121 (New Hampshire) (see Figure 2.2.4-A). Current violations of the National Ambient Air Quality Standards in these regions are shown in Table 2.2.4-A. These violations were detected on the basis of monitoring in urban areas where numerous point sources of pollution exist; the air quality in the rural parts of these regions, where wood harvesting will take place, is probably much better.

Although there has been no monitoring of air quality in rural areas, there is a strong probability that widespread violations of ozone and oxidant standards occur throughout rural New

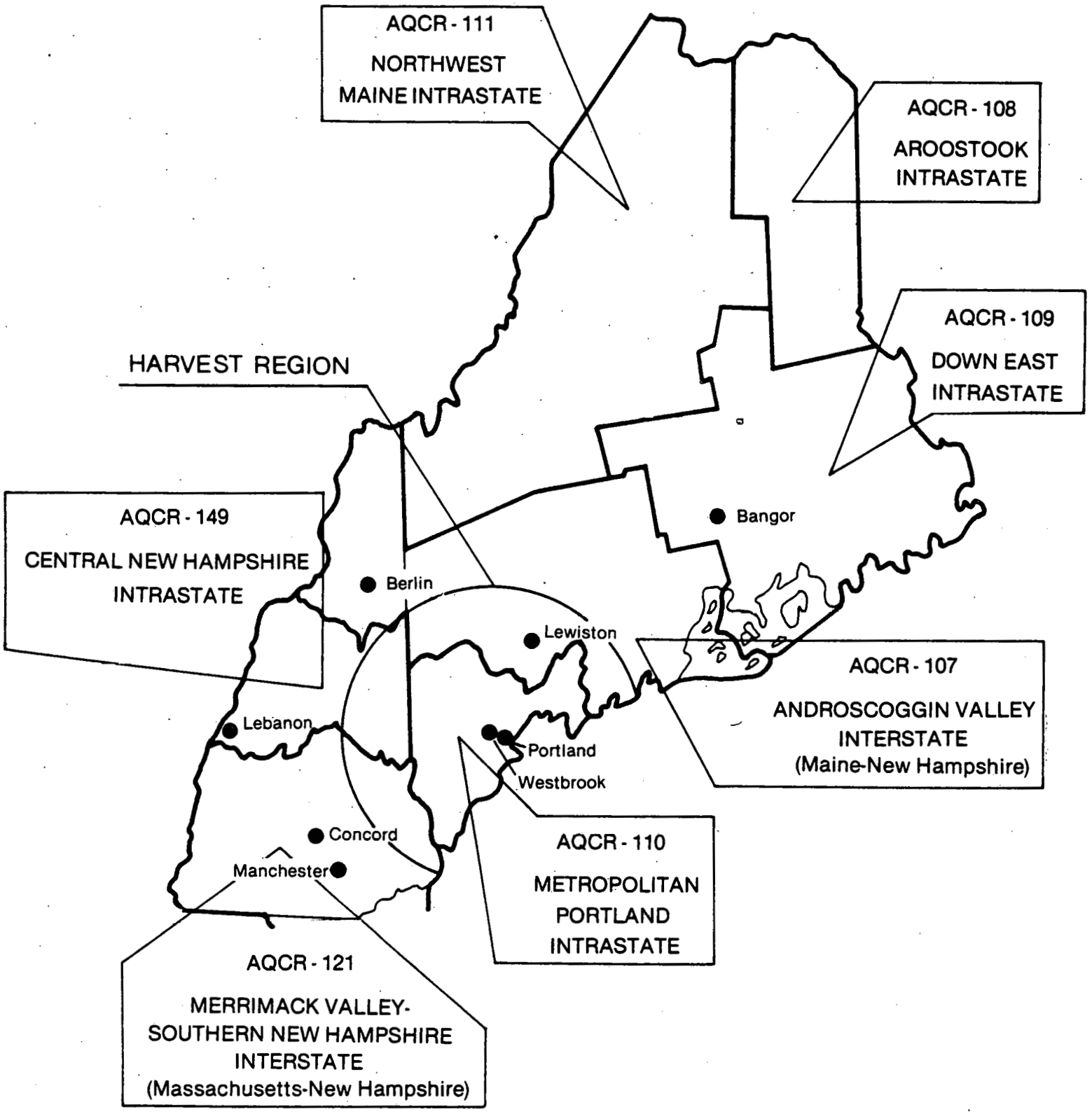


FIGURE 2.2.4-A: AIR QUALITY CONTROL REGIONS

TABLE 2.2.4-A: AIR QUALITY STATUS OF THE FUELWOOD HARVEST REGION

Pollutants	National Air Quality Control Regions: Maine 107	Maine 110	New Hampshire 107	New Hampshire 149	New Hampshire 121
Total Suspended Particulates (TSP)	v	nv	v	nv	nv
Carbon Monoxide (CO)	v	na	nv	nv	nv
Sulfur Dioxide (SO_2)	nv	nv	v	nv	nv
Ozone (O_3)	na	v	nv	na	v
Nitrogen Dioxide (NO_2)	na	v	nv	nv	nv

---

v indicates violation of National Ambient Air Quality Standard.

nv indicates no violation.

na indicates data is not available.

Source: EPA 1978.

England, including the fuelwood harvest region. These conditions, especially in the coastal regions, may result from the drifting of ozone and ozone-forming pollutants from the New York-Boston areas. Alternatively, they can be caused by local interactions of automobile emissions with chemicals given off by vegetation. In small valleys, under conditions of very low wind speed, these reactions may lead to ozone concentrations significantly higher than regional norms.

2.2.5 Terrestrial Ecology

Flora

The proposed fuelwood harvest region is abundantly forested. Commercial forestland covers about 1.8 million acres of the area within a 50-mile radius of Westbrook. None of the ten counties wholly or partially included in the fuelwood harvest region has less than 70 percent forest cover (Kingsley 1976; Ferguson & Kingsley 1972).

Forest types. The forest types of Maine and New Hampshire have been categorized by a variety of schemes, but three broad classifications can be used to describe the major types which dominate the various regions of the two states: hardwood-pine, northern hardwood, and spruce-fir (see White 1976; Ferguson & Kingsley 1972; Westveld 1956). Principal tree species of each type are listed in Table 2.2.5-A.

As shown in Table 2.2.5-B and Figure 2.2.5-A, the most prevalent forest type in the proposed harvest region is hardwood-pine (Ferguson & Kingsley 1972). White pine and, to a lesser degree, red pine and a variety of hardwoods dominate this type. In northern areas, beech, birch, and maple make up the hardwood component of these forests, and red spruce and balsam fir are also found. Hickory, oak, and pitch pine are characteristic of this forest type in the more southerly regions of the harvest region (Westveld 1956; McKinnon, Hyde & Cline 1935). Hemlock, white ash, black cherry, and red maple occur commonly in this type in all geographic regions. The large variety of species in this forest class (most hardwoods indigenous to New England have

TABLE 2.2.5-A: PRINCIPAL TREE SPECIES OF THE THREE FOREST TYPES IN THE FUELWOOD HARVEST REGION

SPECIES	HARDWOOD-PINE	NORTHERN HARDWOOD	SPRUCE-FIR
Striped Maple		x	
Red Maple	x	x	x
Sugar Maple		x	x
Mountain Maple		x	
Yellow Birch		x	x
Paper Birch	x	x	x
Shagbark Hickory	x		
American Beech		x	x
White Ash	x	x	
Quaking Aspen	x	x	x
Bigtooth Aspen	x	x	x
Pin Cherry	x	x	x
Black Cherry	x	x	
Basswood	x		
Red Oak	x		
Balsam Fir		x	x
Black Spruce			x
Red Spruce		x	x
White Spruce			x
White Pine	x	x	
Red Pine	x		
Pitch Pine	x		
Hemlock	x	x	

TABLE 2.2.5-B: AREA OF COMMERCIAL FOREST LAND BY FOREST TYPES IN MAJOR COUNTIES IN THE FUELWOOD HARVEST AREA[1]

(thousands of acres)

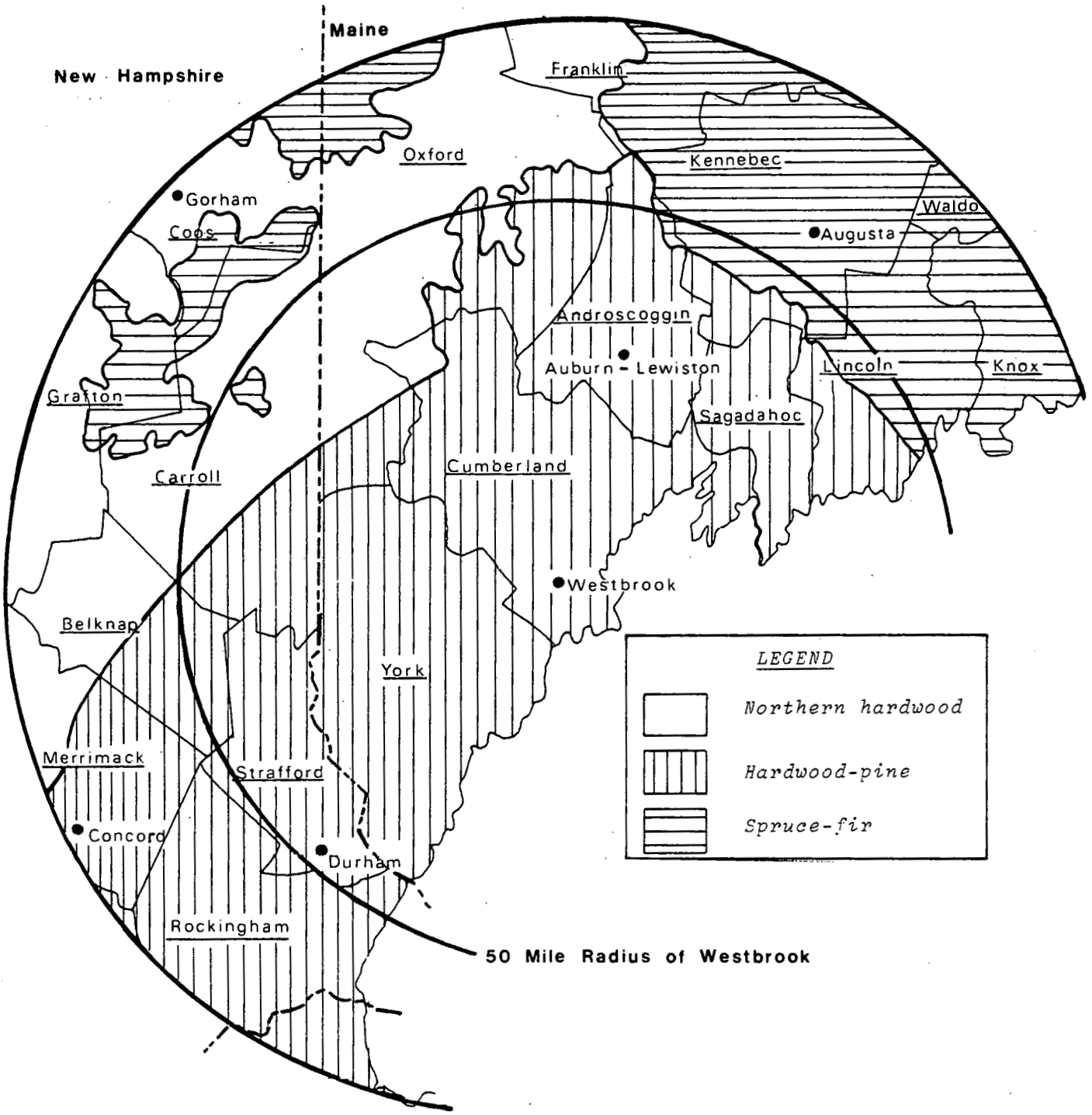
COUNTY	HARDWOOD-PINE	NORTHERN HARDWOOD	SPRUCE-FIR
Androscoggin (ME)	140.9	72.7	14.7
Cumberland (ME)	252.4	156.8	21.4
Lincoln (ME)	66.2	84.5	66.7[2]
Sagadahoc (ME)	82.0	40.7	7.6
York (ME)	385.1	193.4	20.4
Carroll (NH)	107.9	284.1	122.8[2]
Strafford (NH)	103.4	75.0	3.1
TOTALS	1,137.9	907.2	256.7

1. *Belknap (NH), Oxford (ME), and Kennebec (ME) Counties also have small fractions of land area in the 50-mile fuelwood harvest region.*

2. *Carroll County (NH) and Lincoln County (ME) contain substantial acreages of spruce-fir forest that is outside the fuelwood harvest region boundary. This has been included for the sake of consistency, but it should be noted that the proportion of spruce-fir forest above exceeds that actually within the 50-mile radius of Westbrook.*

Source: Adapted from Kingsley 1976 and Ferguson & Kingsley 1972.

FIGURE 2.2.5-A: FOREST TYPES IN THE FUELWOOD HARVEST REGION



Sources: Kingsley 1976: Ferguson & Kingsley 1972.

at least some representation) is somewhat atypical of northern forests. It occurs because of the transitional characteristic of the hardwood-pine forest, which lies between the boreal and deciduous types (McKinnon, Hyde & Cline 1935).

The northern hardwood forest is the second most common in the fuelwood harvest region. Sugar maple, yellow birch, and beech make up about 80 percent of the stand composition in this forest type. Other trees common to this category include red maple, balsam fir, and red spruce. As the hardwood forest blends into the hardwood-pine type to its south, white pine and hemlock become more abundant than the balsam fir and red spruce found increasingly intermixed to the north. White ash, black cherry, sweet birch, paper birch, northern red oak, American elm, and basswood also become more frequent in the southern portion of this type.

Although the spruce-fir type occupies 47 percent of Maine's forest land area and 14 percent of New Hampshire's forest acreage, it occurs only in scattered pockets in the harvest region, except at the northeast extremity. Red spruce and balsam fir account for about 75 percent of the composition of the spruce-fir stands. Heartleaved paper birch, yellow birch, and red maple make up most of the remainder.

Forest succession. Like all ecosystems, the forest communities of the proposed fuelwood harvest region are characterized by continuous change. This change occurs because species of forest vegetation have differing abilities to regenerate and grow under varying environmental conditions. In other words, each plant has a characteristic "preference" for a certain range of combinations of available light, temperature, moisture, and nutrients. As these variables change during the development of the forest, their combination becomes less favorable for some species, which will decline, and more propitious for other species, which will proliferate. This process by which the composition of any ecosystem progresses from one form to another is called ecological succession. It is a process which is continuous, ultimately cyclical, and, to a degree, predictable.

However, there are species which, under certain environmental conditions, will maintain their own preferred conditions for long periods of time and thus will succeed themselves one generation after another. These species occur at the later stages of succession and are called climax species since, at least theoretically, their ability to self-perpetuate temporarily ends the successional process until a disturbance such as fire, wind, or pest damage occurs to reinitiate it (Whittaker 1975).

When such a disturbance occurs in the forest, succession is interrupted, and, depending on the type and size of the interference, the process retrogresses to some earlier stage. As a rule, the more severe and extensive the disturbance, the earlier the stage of succession that takes hold in its wake. In the harvest region, large-scale disturbances might result from extensive windfall, fire, or clearcutting. The occurrence of small disturbances usually is related to localized outbreaks of tree disease or insects, windthrow, selective harvesting, or damage from ice, lightning, hail, or snow. These disturbances can create an uneven-aged forest.

The course of succession after a disturbance may or may not follow that which occurred prior to the disturbance, depending on the type and size of the disturbance (White 1976; Davis 1966; Marks 1975; Forcier 1975). The succession of forest species after land clearing depends largely on the use to which the cleared land was put before its abandonment. Forest development on old pastureland, for instance, differs from that on old cropland.

The size of openings in the forest canopy will determine the degree to which the forest floor is exposed and thus the environment in which the succeeding forest must grow. This factor in combination with the available seed source, which is also affected by harvest intensity, shapes the course of succession. Because succession is somewhat predictable, it can be influenced by the method and arrangement of timber cutting applied to a forest. In Figures 2.2.5-B through D, some typical trends in the succes-

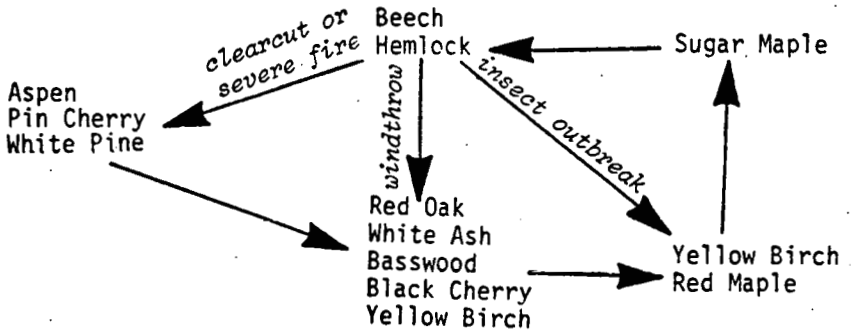


FIGURE 2.2.5-B: REPRESENTATIVE SUCCESSIONAL DYNAMICS IN A NORTHERN HARDWOOD FOREST

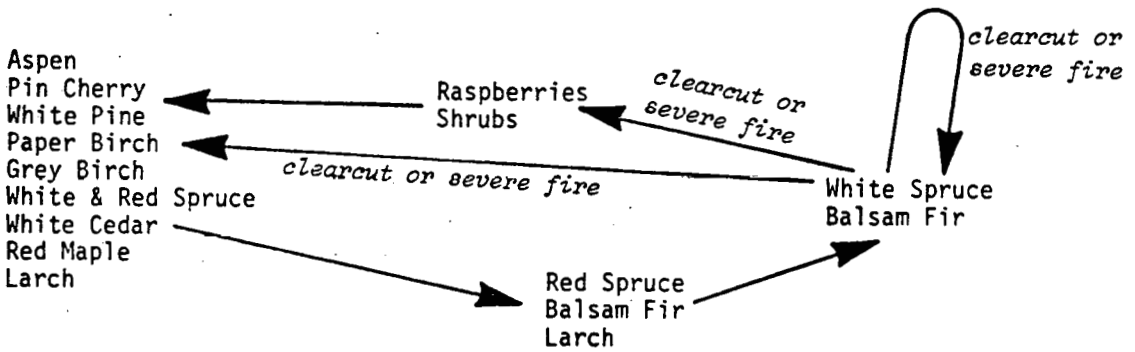
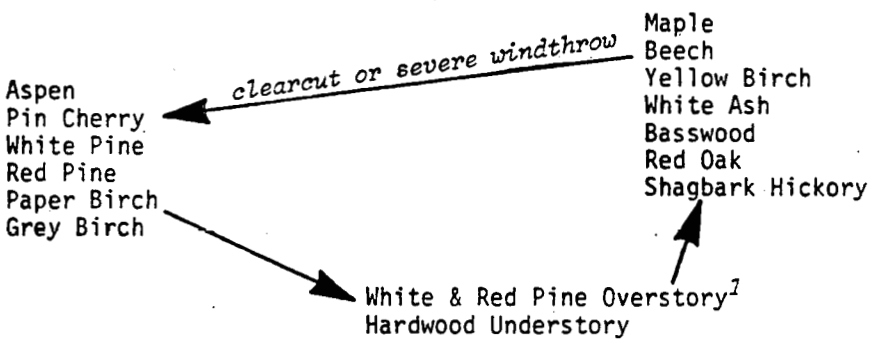


FIGURE 2.2.5-C: REPRESENTATIVE SUCCESSIONAL DYNAMICS IN A SPRUCE-FIR FOREST



1. A forest overstory is the tallest trees, those that comprise the upper canopy.

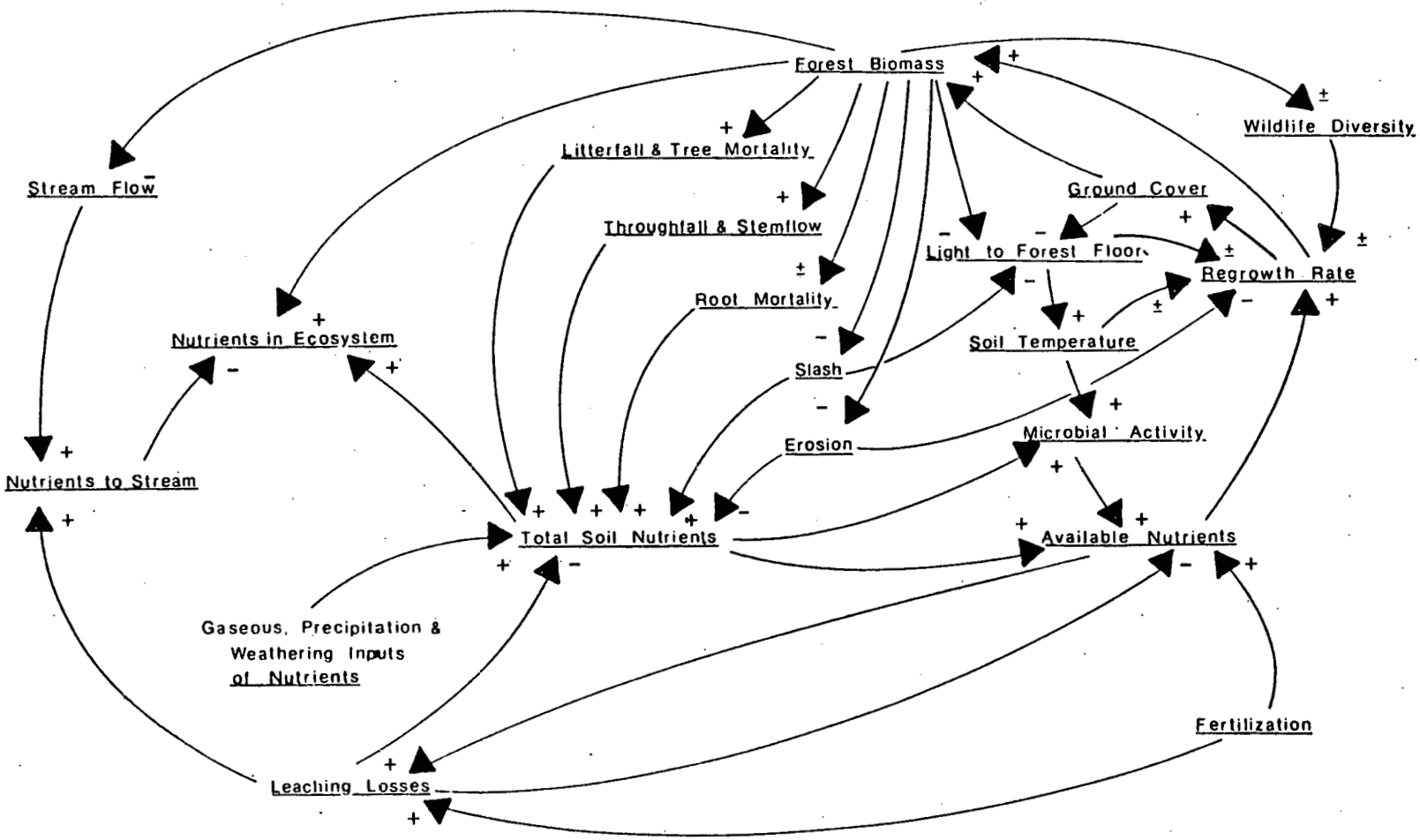
FIGURE 2.2.5-D: REPRESENTATIVE SUCCESSIONAL DYNAMICS IN A PINE-HARDWOOD FOREST

sional dynamics of the three forest types identified in the harvest region are presented.

Forest nutrient cycling. The nutrient budget of any ecosystem plays a critical role in its development. Inputs to the budget consist of nutrients in precipitation, the contribution from chemical weathering of the parent material, and gaseous uptake from the atmosphere. Outputs are nutrients that leave the forest in ground water or surface flow, and gaseous losses to the atmosphere (Likens et al. 1977). Within the forest ecosystem of the harvest region, the organic matter in the soil is the largest reservoir of nutrients (see Appendix D). These soil nutrients can be available for plant uptake or unavailable. Nutrients are unavailable to plants when they are in a chemical state which renders them unusable or when they are chemically bound in the soil, frequently to clay particles, for example. Nutrients continually cycle along numerous biological, geological, and chemical pathways throughout the biospere, though they may be immobilized (e.g., in soil litter or woody material for varying lengths of time). These processes are described in Appendix D. In the forest ecosystem, the nutrients enter the plant from the soil and the atmosphere and eventually become part of the woody tissues or the leaves. This organic matter either: 1) returns to the forest floor as litterfall; 2) flows out of the standing vegetation to the forest floor in such processes as leaf washing, stemflow, or root exudation, or 3) is incorporated into the forest floor (the humus) after the vegetation dies. Soil microorganisms are responsible for the subsequent transformation of many nutrients, especially nitrogen and sulfur, into forms both available and unavailable for uptake by the vegetation.

The compartments and interconnections of the nutrient budget of an ecosystem are shown in Figure 2.2.5-E. To provide a more detailed understanding of the movement, complexity, and importance of nutrients in a forest ecosystem, a synopsis of the cycles of the major nutrients -- nitrogen, phosphorus, sulfur, calcium, potassium, and magnesium -- is provided in Appendix D.

FIGURE 2.2.5-E: DYNAMICS OF THE FOREST ECOSYSTEM NUTRIENT BUDGET



In this diagram, an arrow indicates that a change in one element causes a change in the other. A + sign at the head of the arrow indicates that as the variable at the tail of the arrow increases or decreases, the variable at the head also increases or decreases. A - sign indicates the influence is opposite; as the variable at the tail decreases, the other increases, and, conversely, if the first increases, the second decreases.

Rare and endangered species. Only one plant in Maine, the Furbish lousewort, has been federally designated as an endangered species (USFWS 1978). Several other plant species have been proposed for this listing, and a wide variety of additional species are recognized by botanists to be rare or unusual in Maine. To date, the lousewort has been found only along the banks of the St. John River. Research indicates that the range of the lousewort is restricted to this area (Nickerson 1979) which is well outside of the proposed fuelwood harvest region.

Of the species proposed for endangered listing, only one, the small whorled pogonia, could be affected by harvests in the fuelwood region. This orchid grows in dry or moist leaf mould under mixed hardwood forests (Eastman 1977). The small whorled pogonia is very sparsely distributed throughout the North Atlantic states east of the Mississippi River, with the majority of sites occurring in the New York-New England area (Eastman 1977). Of the four sites that have been reported in the fuelwood harvest region, one in North Sebago, Maine, has been proposed for inclusion in the Maine Register of Critical Areas.

Fauna

Forest wildlife. Because each animal species has specific habitat needs, vegetative changes of succession alter the wildlife composition of an ecosystem. Some species prosper in early successional stages (for example, New England cottontail rabbits and the American goldfinch), while others inhabit the later successional stages of a forest type (e.g., the fisher and the pileated woodpecker). The majority of species, however, are best-adapted to the edges of ecosystems where they can capitalize on two adjacent vegetative types for the critical resources of food, water, and shelter. Examples of edge-inhabiting species include the white-tail deer, the raccoon, the chestnut-sided warbler, and the ruffer grouse. The wildlife of the fuelwood harvesting region is discussed in more detail in Appendix D.

Rare and endangered species. The bald eagle and short-nosed sturgeon are the only species of fauna known to exist in

Maine that have been designated as endangered under the Endangered Species Act of 1973 (USFWS 1978; Gramlich 1979; Squiers 1979). Direct interference with bald eagles is prohibited under the Endangered Species Act of 1973, as amended, and the Bald Eagle Act of 1940. A successful identification and protection program is now underway, conducted by the U.S. Fish and Wildlife Service in cooperation with the state of Maine. The location and habits of the few eagles that nest on the periphery of the fuelwood harvest region have been well documented and protected by this program (Gramlich 1979).

The historical distributions of the eastern cougar, grey wolf, Indiana bat, all listed as endangered, extend into the fuelwood harvest region (USFWS 1978). Current populations in this region, however, are nil and the species are not scheduled for reintroduction efforts at this time (Nickerson 1979). The peregrine falcon, also an endangered species, may migrate through the harvest region but does not use the region for nesting and breeding (Nickerson 1979).

2.2.6 Aquatic Ecology

The ecology of any delineated aquatic system is determined by local geology, topography, hydrology, temperature, and other site-specific physical characteristics. Not only is each aquatic ecosystem unique, but it is also dynamic, changing whenever the physical environment is changed in any way. For these reasons, a discussion of the aquatic ecology of the fuelwood harvest region, an area that includes six major river basins and hundreds of lakes and ponds, is necessarily general. The systems described here represent environments "typical" of the study area.

Stream-River Ecosystems

Cold-water streams. The headwaters of the rivers in the fuelwood harvest region are generally characterized by small, cold-water streams, most of them fast-flowing and having rock, cobble, or gravel substrate (Cowardin, Golet & LaRoe 1977; ACE 1977). Cold temperatures, shade, and fast currents limit primary

productivity (i.e., photosynthesis) in these streams, and usually no phytoplankton are present. The aquatic community depends on nutrient inputs from terrestrial sources, mostly leaves (ACE 1977). Certain mosses (e.g., Fontinalis), clinging algae (e.g., Cladophora), and possibly some perennial emergent plants, such as cattails and bullrushes, may be present in scattered areas of these streams. Surface-dwelling insects are not present due to lack of surface tension in fast-flowing waters. The predominant invertebrates inhabiting stream bottoms are cadisflies, midge and blackfly larvae, and mayfly nymphs (ACE 1977; Odum 1971). Feeding on these may be carnivorous hellgrammite larvae, as well as fish species, especially brook trout, sculpin, chub, and dace (ACE 1977). Shad, salmon, and trout spawn in these types of streams (Scarola 1973). Vertebrates other than fish are not prevalent in cold-water streams, although some species of salamanders, turtles, and frogs may occur.

Warm-water streams. Slower-flowing, warmer waters characterize the broad channels and backwaters of large rivers such as the lower Kennebec, Androscoggin, and Saco. In these waters, phytoplankton and zooplankton can exist (Maitland 1978). Bluegreen algae are usually dominant but many other aquatic algae are also present, including green algae, brown algae, euglenoids, and fire algae (Odum 1971; USGS 1977a). Emergent plants, rooted plants with floating leaves such as water lilies, and submergent vegetation such as pond weeds are usually abundant in littoral regions of the stream (i.e., along the banks).

A diversity of animals find food and shelter in the vegetation of the littoral zone. The major invertebrate organisms are listed in Appendix C. Fish species in the warmer, slow-moving, weedy sections of the stream include carp, perch, largemouth and rock bass, bullheads, and white suckers. Fish such as shad, salmon, and trout will be present briefly during their migration to upstream spawning areas (Scarola 1973). Numerous amphibians (e.g., frogs, toads, salamanders, newts), turtles, and aquatic birds (e.g., ducks, geese, loons, grebes) thrive in the littoral

zones of warm-water streams. River otters, beaver, water shrews, and muskrats are aquatic mammals that may be present.

Lake Ecosystems

There are hundreds of lakes and ponds in the fuelwood harvest region, including twenty-five that are larger than one thousand acres (Anderson & Strunk 1973). The majority of the lakes and ponds, however, are small and shallow--the result of Pleistocene glaciation (Brooks & Devey 1966). Standing bodies of water may be very generally classified biologically as eutrophic, oligotrophic, or dystrophic. The characteristics of each of these kinds of systems are summarized in Table 2.2.6-A.

The majority of lakes and ponds in the fuelwood harvest region are mesotrophic and have characteristics midway between eutrophic and oligotrophic. As in warm, slow-moving streams, the most biologically productive area of a body of standing water is the littoral zone. Most of the plant and animal species present in warm-water streams will also be found in lakes (Odum 1971). The midge Chaoborus is normally dominant in these lakes (Maitland 1978).

Rare and Endangered Species

A number of plant and animal species that may inhabit or depend on the aquatic ecosystems of the fuelwood harvest region have unique or noteworthy biological or aesthetic value. These species have been designated as suitable for inclusion in state and local conservation program listings (see Appendix C). Included on this list are two species that are listed as endangered or threatened under the Endangered Species Act of 1973: the short-nosed sturgeon and bald eagle.

Species of Commercial and/or Recreational Value

Several fish of commercial importance spawn in the streams of the harvest region. They include alewife, blueback herring, shad, and Atlantic salmon. Important game fish are: lake whitefish, trout (brown, rainbow, brook, lake), Atlantic salmon, rainbow smelt, chain pickerel, brown bullhead, white perch, bass (small- and largemouth), yellow perch, and walleye (Scarola 1973; MBPR 1977).

TABLE 2.2.6-A: CHARACTERISTICS OF LAKES AND PONDS

Character	Eutrophic	Oligotrophic	Dystrophic
Basin shape	Broad and shallow	Narrow and deep	Small and shallow
Lake substrate	Fine organic silt	Stones and inorganic silt	Peaty silt
Lake shoreline	Weedy	Stony	Stony or peaty
Water transparency	Low	High	Low
Water color	Yellow or green	Green or blue	Brown
Dissolved solids	High, much N and Ca	Low, poor in N	Low, poor in Ca
Suspended solids	High	Low	Low
Oxygen	High at surface, low under ice or thermocline	High	High
Phytoplankton	Few species, high numbers. Cyanophyceae typical	Many species, low numbers. Chlorophyceae typical	Few species, low numbers
Macrophytes	Many species, abundant in shallow water	Few species, rarely abundant but found in deep water	Few species, some abundant in shallow water
Zooplankton	Few species, high numbers	Many species, low numbers	Few species, low numbers
Zoobenthos	Few species, high numbers	Many species, low numbers	Few species, low numbers
Fish	Many species, especially Cyprinidae	Few species, Salmonidae characteristic	Very few species, often none

Source: Maitland 1978.

Between twenty-five and thirty species of ducks and three species of geese are hunted for recreation in the state of Maine. Important species include: Canada goose, black duck, common goldeneye, wood duck, green-winged teal, blue-winged teal, bufflehead, ring-necked duck, and three species of mergansers (MBPR 1977).

Muskrat and beaver are of commercial value to the fur industry.

2.2.7 Land Use

Historical Land Use

Earliest settlement in Maine occurred on the coast and along the major rivers where water provided ready transportation corridors and timber and fish supported subsistence as well as a market economy. Later, settlement expanded to areas with terrain and soils suitable for agriculture. Ports with good harbors thus developed into the first "urban" centers; inland towns grew where flowing water could power both grist and sawmills. With the industrial revolution, textile and shoe factories strengthened the economic base and increased the populations of towns with developable water power sites. While the population of the state has increased since 1860, the migrations of the agricultural community from the farms of New England to the more productive lands of the Midwest caused the geographic area of settlement in the proposed harvest region to decline. By 1900, the present settlement patterns were well established and highway development and public services have maintained, rather than altered, established land-use patterns (MSPO 1978).

Present Land Use

Forests. About 70 to 95 percent of each county in the fuelwood harvest region is forested (see Tables 2.2.7-A and 2.2.7-B). These forests serve many purposes, including timber and fiber production, dispersed recreation, and primary and seasonal homesites.

TABLE 2.2.7-A: LAND USE IN MAINE COUNTIES COMPRISING FUELWOOD HARVEST REGION[1]

USE	COUNTY													
	Androscoggin		Cumberland		Kennebec		Lincoln		Oxford		Sagadahoc		York	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Federal Land	154	-	4,216	-	1,313	-	53	-	47,000[2]	4	0	-	4,128	-
Urban & Built Up	25,805	8	40,023	7	26,232	5	12,452	4	15,881	1	5,180	4	32,088	5
Small Water Area	1,200	-	1,250	-	2,635	-	800	-	6,200	-	1,084	-	6,420	1
Crop & Pasture	52,564	17	62,102	11	104,441	19	20,750	7	54,828	4	14,720	9	77,257	12
Forest[3]	214,431	70	447,009	79	408,252	74	245,200	84	1,173,441[2]	88	138,520	84	491,757	77
Other	11,766	4	9,240	2	10,727	2	13,225	5	37,050	3	4,976	3	28,350	4
TOTAL ACRES	305,920		563,840		553,600		292,480		1,334,400		164,480		640,000	

- Less than 1%.

1. *Adapted from SCS-ME 1970 (1967 data); land uses shown are for entire counties, not just areas in fuelwood harvest region.*
2. *Total forested land for county is 1,220,441 acres (92%), including the White Mountain National Forest land shown here as federal land.*
3. *Forest land totals differ from Ferguson & Kingsley 1972 due to different sampling scheme and error. Also, SCS data include noncommercial forest land.*

TABLE 2.2.7-B: LAND USE IN NEW HAMPSHIRE COUNTIES COMPRISING FUELWOOD HARVEST REGION[1]

USE	COUNTY					
	Belknap		Carroll		Strafford	
	Acres	%	Acres	%	Acres	%
Federal Land	1,300	-	144,991	24[2]	0	0
Urban & Built Up	9,800	4	7,400	1	11,710	5
Small Water Areas	1,850	-	2,050	-	1,980	-
Crop & Pasture	12,450	5	9,864	2	16,260	7
Forest[3]	220,300	86	410,800	68[2]	200,700	83
Other	10,300	4	25,215	4	10,248	4
TOTAL ACRES	256,000		600,320		240,898	

- Less than 1%.

1. *Adapted from SCS-NH 1970 (1967 data); land uses shown are for entire counties, not just areas in fuelwood harvest region.*
2. *Total forested land for Carroll County is 555,791 acres (92%), including the White Mountain National Forest land included here as federal land.*
3. *Forest land totals differ from Kingsley 1976 due to different sampling scheme and error. Also, SCS data include noncommercial forest land.*

Agriculture. Farming occurs on 2 to 19 percent of each county in the fuelwood harvest region. Major agricultural products include chicken and egg production, milk and dairy products, fruits, potatoes, and other vegetables. Like forests, agricultural lands are also important as multiple-use open space.

Urban land. Ten of Maine's sixteen largest cities are located in the harvest region (MBPR 1977) and 23 percent of the state's population lives in them (Census 1977). Two urban areas are located in the New Hampshire portion of the proposed harvest area. The use of the automobile has led to decentralization (suburbanization) of the cities, and both shopping centers and industries have begun to locate outside of downtown areas (Androscoggin 1978).

Recreational land use. The opening of the Maine Turnpike and Interstate 95 caused a major increase in recreational development along the coastal and inland waters of southwestern Maine. More than sixty million people live within three hundred miles of the Maine/New Hampshire border (MVTAC 1974). Supported by easy highway access and a reasonable economic climate, numerous recreational enterprises in southwestern Maine and adjacent New Hampshire attract hundreds of thousands of tourists annually. In addition to established facilities for swimming, camping, tennis, boating, skiing, hiking, golfing, and picnicking, there are many opportunities for more dispersed activities such as hunting, cross-country skiing, and pleasure driving. Motels, restaurants, sporting goods shops, and other retail establishments serving tourists are a prominent land use throughout the proposed fuelwood harvest region, and second home development continues to be significant. Approximately five hundred seasonal homes were built in the seven Maine counties of the harvest region in 1975 (Hasbrouck 1978).

Summary. In short, the proposed fuelwood harvest region is an area of small urban concentrations surrounded by suburbs that melt quickly into forested and agricultural areas where settlement is typically quite dispersed. However, recreational devel-

opment around lakes and in more mountaineous areas to the west has created more concentrated settlements in the hinterland.

2.2.8 Forest Practices

History of Forest Practices

One of the first sawmills in the United States was built in Berwick, Maine, in 1631 (Wackerman, Hagenstein & Mitchell 1966). From this date to the present, the timber industry has more or less continuously followed the same pattern of forest management practices in the region: loggers have selectively cut the best-quality and highest-valued trees for sale to demanding markets. Until about 1800, high-quality white pine cut both for sawlogs and ship masts was virtually the only product of the forest industry in Maine and New Hampshire. After 1850, sawmills began producing spruce and balsam fir lumber. These species were not predominant in the proposed harvest region, however, and white pine continued to be the most soughtafter species. Prior to 1900, the only significant market for hardwood in Maine or New Hampshire was that for oak in the shipbuilding industry. The widespread selective harvest of this species continued the trend of removing only the best-quality wood in the forest.

This practice of cutting only the best quality trees in a stand (called high-grading) leaves only inferior trees for the next harvest and results in the progressive deterioration of a forest's gene pool. Therefore, the quality of trees for future harvests is successively lowered. A variation of high-grading, called diameter-limit cutting, has also been common industry practice in the fuelwood harvest region. In this technique, all trees of a size larger than the minimum considered harvestable are removed from the stand. This system can be simply applied and provides high short-term returns per unit of wood harvested. This practice, however, also removes the fastest growing, most promising, and most vigorous trees and allows no control over the distribution of the cut, the spacing of the remaining trees, or

the type and distribution of regeneration. Again, with this type of harvest, the forest deteriorates.

Present-day Influences on Forest Practices

A number of factors have prevailed throughout the 350-year history of forest use in the region to deter both commercial harvesters and individual landowners from practicing better forest management. As the brief historical sketch above demonstrates, the market for forest products has determined the quality and species of trees harvested from the region's forests. Because there was little demand for low-quality trees before 1900, there was little economic incentive to harvest anything but the highest-quality trees of the most desirable species.

Since 1900, the pulp industry has created a more diverse market for softwoods and, increasingly in recent years, for hardwoods as well. Because the pulping process reduces wood to its fiber content, the industry is less restrictive regarding the size, quality, and species of its raw material than is the sawtimber industry. Pulpwood harvests can include trees as small as five inches in diameter, as well as those with some roughness of form.

Because of the pulpwood market's relative flexibility in accepting materials of varying qualities, some clearcutting of forests has been conducted in the proposed harvest region, particularly in the scattered spruce-fir stands. This harvest technique is generally more cost-efficient for the operator than selective harvests when most of the material in the stand is of pulpwood quality. Like selective harvesting, the environmental impacts associated with clearcutting depend on the application of the technique to a particular ecosystem.

In most pulpwood harvests in the proposed harvest region, however, high grading has continued to be the predominant cutting technique. Despite the less demanding standards for pulpwood, both industrial and harvesting technologies have dictated that trees harvested for pulp be reasonably straight to ensure ease of transportation and handling at the mill. This

means that there still exists no incentive to cut significantly deformed and otherwise unmerchantable trees.

Landowner attitudes have also reduced the use of optimal forest management practices in the area. Forest land within a 50-mile radius of Westbrook is held almost entirely in small, nonindustrial, private parcels. Such ownerships in New Hampshire have an average size of about forty-five acres, a mean that continues to decrease (Hovland 1978; Kingsley 1976). No corresponding statistic is presently available for the state of Maine, but it is certain that the trend, at least in the fuelwood harvest region, is also toward diminishing acreage per parcel and an increasing number of owners.

In effect, most forest land is now held by owners who are not dependent on their land for even a portion of their incomes and whose primary ownership objectives are residential and aesthetic. These landowners typically do not favor clearcutting and may not be inclined to cut any timber for commercial sale. In a recent study of New England landowners who have not harvested timber on their lands, the reason most frequently cited was a concern for impact on "the scenery" (Kingsley & Birch 1977). These landowners have not undertaken deliberate timber stand improvement measures because these efforts typically are unprofitable in terms of the immediate return from the removed material.

Despite these disincentives, two forces have maintained some level of timber stand improvement in the fuelwood harvest region: 1) the efforts of some landowners who associate such practice with good land stewardship; and 2) financial and technical assistance programs such as the U. S. Forestry Incentives Program, the U. S. Agricultural Conservation Program, and various private tree farm programs. These programs make funds and advice available to landowners who wish to manage their lands for future forest production.

Future Forest Practices

Markets. Changing markets for forest products could significantly affect the demand for low-quality wood in the future.

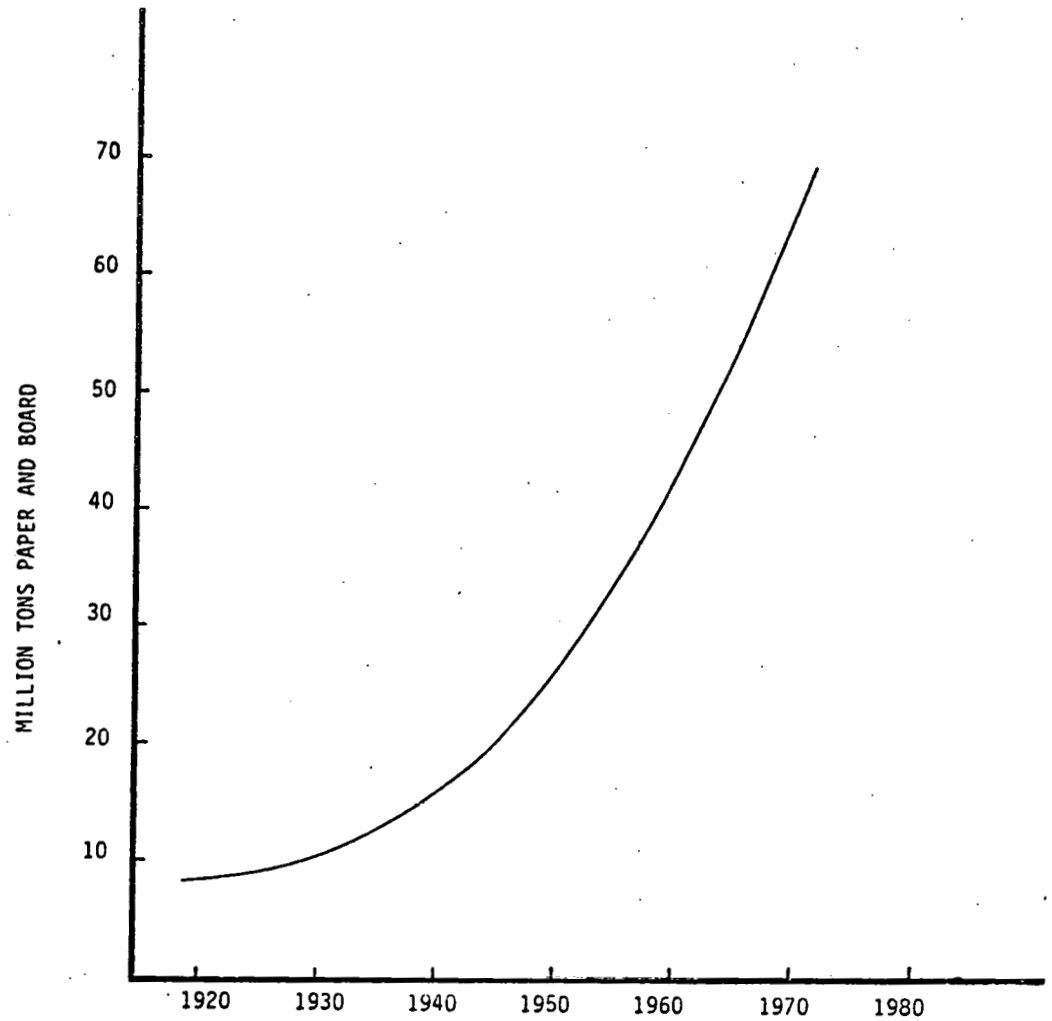
Nationwide, consumption of paper, particle board, and oriented-strand fiberboard is increasing rapidly (see Figure 2.2.8-A) and should continue to do so as reconstituted boards fill the materials gap left by decreasing supplies of products produced from declining stocks of old-growth timber in the western U.S. As demand for these products has risen, the pulpwood industry has increased its reliance on forest materials once left unused.

Over the past twenty years, the proportion of hardwood in the annual pulpwood harvests in Maine has remained constant due to the limitations of Maine pulpmills. These constraints will be greatly reduced as mills and processes are modernized; hardwood will constitute an increasing percentage of the pulpwood cut (Ferguson & Kingsley 1972). In New Hampshire, the hardwood pulpwood harvest has increased dramatically since 1959 (FRG 1978). In addition, the pulp industry is increasing its reliance on whole-tree and mill-residue chips as a raw material. These trends mean that there will be a greater economic incentive for landowners to remove low-quality trees from their property.

With an improving market for a wider variety of tree qualities and species, such as that provided by a wood-fired power plant, landowners will have more flexibility in their approach to forest management. If efficient harvest techniques are developed, trees of lower value, which exist in quantities far greater than the present cut (Sewell 1978), can profitably be thinned or harvested, creating room for improved growth on adjacent trees of better form or species. Landowners would thus have more of an incentive to undertake timber stand improvement and to use harvesting techniques that do not result in high-grading.

Harvest techniques. Currently, the majority of logging contractors in the fuelwood harvest region use conventional harvesting techniques. Each operator has a crew typically consisting of a sawyer, a skidder driver, and a worker in the log landing. Most operators' equipment inventories include several chain saws, a skidder, and a pickup truck. In most cases, the transportation of the logs is contracted to an independent trucker.

FIGURE 2.2.8-A: ANNUAL PAPER AND BOARD CONSUMPTION, 1920 - 1972



Source: USFS 1974.

Some harvest operations in the region are less mechanized. Fuelwood operations rely on convenient access and generally do not include a skidder but only one or two chain saws and a pick-up truck.

Five independent contractors in the study area currently run whole-tree chipping operations. These activities, at their most mechanized level, depend on feller bunchers to cut and stack whole trees, grapple skidders to forward the trees to the chipping site, and mobile whole-tree chippers which convert the logs to chips and blow the chips into semitrailer vans. This type of harvest operation could lead to increased clearcutting of hardwoods, as this approach is most cost-efficient from the operator's standpoint. The effects of such operations could be either good or bad, depending on the care with which they were applied and the ecosystems that were involved. Whole-tree removals could also be conducted as thinning or selective harvest techniques and could consequently lead to significant improvement of the region's timber stands if forest management with a sound, long-term view could be encouraged.

2.2.9 Socioeconomic Profile

Description

The fuelwood harvest region within a 50-mile radius of Westbrook encompasses the following Maine counties: all of Cumberland, York, and Sagadahoc; the southern quarter of Kennebec; and approximately two-fifths of Lincoln, seveneighths of Androscoggin, and one-third of Oxford. The potential harvest region includes Maine's two metropolitan areas, Portland and Lewiston-Auburn, plus its capital, Augusta. Three New Hampshire counties lie partially within the harvest region: Belknap, Carroll, and Strafford. None of these counties contains a federally recognized "metropolitan area"; the largest city in the region is Dover in Strafford County.

Population Growth and Growth Trends

The seven Maine counties have shown steady population growth

since 1950, but at rates below the national average of 34 percent over that period. Five of these counties grew at a rate above the national average of 5.3 percent for the fiveyear period from 1970 to 1975, as shown in Table 2.2.9-A. Within each county, the population of major cities has declined through migration to the suburbs. All the counties in New Hampshire have experienced growth at rates above the national average since 1950 (see Table 2.2.9-A). The growth in Strafford County is due partially to advancement of Boston suburbs, and partially because many businesses are locating in southern New Hampshire.

Housing

In 1970, there were approximately 17,500 vacant housing units out of 196,991 year-round units throughout the seven Maine counties in the harvest region (Census 1970). Estimates of current vacancy rates for each county are found in Appendix E. In the urban areas, the housing situation is generally tighter than in rural areas.

In 1970, there were 43,698 existing units in the three New Hampshire counties (Census 1970), with 6,551 vacant. Carroll County has a tight housing situation caused by a large increase in population from 1970 to 1976.

Income and Employment

In the first quarter of 1978, annual per capital income was $4,308 in Maine and $4,917 in New Hampshire (Wharton 1978). Total personal income received in Maine during the first three months of 1978 was $6.8 billion; in New Hampshire it was $6.2 billion. Annual projected 1978 total personal incomes in the two states were, therefore, $27.2 billion and $24.8 billion, respectively (Wharton 1978).

In Maine's section of the potential fuelwood harvest region, there were an average of 269,610 persons employed in 1978, a 2 percent increase over 1977 (MDMA 1978a). Forty-two percent of the jobs were within the Portland and Lewiston-Auburn metropolitan areas. In May of 1978, the civilian labor force of the three

TABLE 2.2.9-A: POPULATION GROWTH IN TEN COUNTIES COMPRISING FUELWOOD HARVEST AREA

County	Population			Rate of Change (%)	
	1950	1970	1975	1950-1975	1970-1975
Androscoggin, ME	83,594	91,279	93,863	12.3	2.8
Cumberland, ME	169,201	192,528	202,972	19.9	5.4
Kennebec, ME	83,881	95,247	100,647	19.9	5.7
Lincoln, ME	18,004	20,537	23,163	28.5	12.7
Oxford, ME	44,221	43,457	44,459	0.5	2.3
Sagadahoc, ME	20,911	23,452	26,459	26.5	12.8
York, ME	93,541	111,576	121,499	29.9	8.9
Belknap, NH	26,632	32,367	35,900	34.8	10.9
Carroll, NH	15,868	18,548	22,600	42.4	21.8
Strafford, NH	57,567	70,431	77,800	35.1	10.5

Sources: Census 1960, 1970, 1976.

New Hampshire counties potentially affected by WFPP harvesting totaled 75,780, up 9 percent from 1977 (NHDES 1978b).

Within the Maine portion of the fuelwood harvest region, there are 292 logging firms (MDC undated) employing between eight hundred and one thousand loggers (Census 1976b). There are currently six hundred loggers in the state of New Hampshire; their number is expected to increase moderately through 1985 (NHDES 1977a).

In 1978, an average of 14,810 individuals were reported to be unemployed in the seven Maine counties, a jobless rate of 5.2 percent (MDMA 1978b). Unemployment has been falling since 1975, when it averaged 8.6 percent (MDMA 1978c&d). In May of 1978, 1,880 persons were unemployed in the three New Hampshire counties. Belknap had an unemployment rate of 2.2 percent, and the rate for both Carroll and Strafford was 2.6 percent. Unemployment has been dropping since 1975 (NHDES 1978b). A categorization of the insured unemployed is provided in Table 2.2.9-B.

Education

The state of Maine reached a peak grade school enrollment of 247,031 pupils in 1972. School enrollments have declined since then in response to lowered birth rates. In the seven counties, enrollment has been declining since 1972 and stood at 138,367 in 1976-1977 (MDECS 1977b). Total education expenditures for 1976-1977 for the state of Maine were $249,234,725, for a state average per pupil expenditure of $1,041.20 (MDECS 1977a). The average student/teacher ratio was 18:1. In 1976-1977, local sources paid for 49.9 percent of school expenditures, state sources paid for 48 percent, and the federal government paid for 2.1 percent.

Inmigration has offset declining birth rates in parts of the three New Hampshire counties. School enrollments in Carroll and Strafford Counties have thus grown. School expen- ditures in New Hampshire towns are determined by local property taxes, since there is no state aid to local schools.

Student/teacher ratios vary by county in both states, as do median school years completed (see Table 2.2.9-C).

TABLE 2.2.9-B: DISTRIBUTION OF INSURED UNEMPLOYED IN THE FUELWOOD HARVEST REGION

Maine - June 1978

Sector	% Unemployed
Professional, Technical, & Managerial	16.8
Structural Work	16.7
Miscellaneous	15.7
Clerical & Sales	14.4
Services	10.5
Processing	9.5
Bench Work	8.3
Machine Trades	6.6
Farming, Forestry, Fishing, & Related	1.5

New Hampshire - January 1978

Manufacturing	26.9	
Durable goods		10.4
Nondurable goods		16.5
Nonmanufacturing	73.1	
Construction		41.2
Trade		14.3
Services		11.3
Other nonmanufacturing		6.3

Sources: MDMA 1978a; NHDES 1978b.

TABLE 2.2.9-C: EDUCATIONAL CHARACTERISTICS OF FUELWOOD HARVEST REGION

Maine: 1976-1977

County	Total enrollment	Student/teacher ratio	Median school years completed
Androscoggin	20,423	20:1	10.8
Cumberland	43,905	18:1	12.3
Kennebec	22,717	18:1	12.1
Lincoln	5,147	16:1	12.1
Oxford	11,709	18:1	12.0
Sagadahoc	6,763	18:1	12.1
York	27,703	20:1	12.0

New Hampshire: 1976-1977

Belknap	8,346	20:1	12.1
Carroll	5,017	18:1	12.3
Strafford	15,433	21:1	12.1

Source: for Maine data-MDECS 1977a and Census 1970; for New Hampshire data-NHDE 1978 and Census 1970.

Health, Public Assistance, and Social Services

There are approximately thirty-five hospitals within the 50-mile fuelwood harvest region. Both Maine and New Hampshire offer public assistance and social services programs characteristic of rural areas.

Economic Base

Sectors of the economy. The industrial base contained within the seven Maine counties includes many types of manufacturing as well as forestry, agriculture, and a substantial tourist industry. Growth in the tourist industry is reflected in the expansion of trade and services. Health services have also increased in the past few years. Manufacturing is recovering from the recession, with particular strength in the nonelectrical machinery production sector. Leather and leather products, and the textile and apparel industries have recently seen marginal growth (MDMA 1978c).

Lumber and wood products, furniture and fixtures, and paper and allied products industries employ approximately 6 percent of the total labor force in the fuelwood harvest region. Logging makes up .43 percent of the total. All forest-related sectors have seen moderate growth since 1977 (MDMA 1978b; NHDES 1978b).

As in Maine, the industrial base for each county in New Hampshire is different. Strafford is far more industrialized than Belknap, which, in turn, is more industrialized than Carroll. Services and wholesale and retail trade are expanding sectors of the economy. As in Maine, they should continue to grow with the tourist industry.

Taxes. Property tax in each Maine community is greatly influenced by the expenditures of the local school system. The Maine sales tax is 5 percent of all tangible personal property sold for use or consumption within the state. The state corporate tax is 5 percent on the first $25,000 of net income and 7 percent on all income in excess of $25,000 per year.

Taxation of designated forest lands in organized townships is based on the tree growth tax law. Valuation of these lands for assessment purposes is arrived at via the tree growth tax

law adjusted by the town's assessment ratio: namely, the town valuation of property divided by the state's valuation.

In the state of New Hampshire, there is a local property tax determined by the needs of the individual town. The state has a business profits tax of 8 percent on taxable business profits. The state imposes a limited tax of 7 percent on investment income. There is no state personal income or sales tax, and no state aid for schools.

2.2.10 Historic, Archaeologic, Cultural, and Aesthetic Resources

History

Prehistoric man arrived in northern New England more than ten thousand years ago. The early inhabitants--hunters, gatherers, and fishermen--lived a nomadic existence; agriculture did not develop until after the first century. Seasonal migrations took place along the river valleys as man followed the availability of food sources (Soule 1975).

European explorers first visited the northern New England coastline in the sixteenth century. In 1622 Ferdinando Gorges and John Mason acquired an English charter for the land bounded by the Merrimack and Kennebec Rivers. In 1629 this tract was divided down the Piscataqua River. The land to the river's north became known as the Province of Maine and land to the south as New Hampshire (Lewis 1968).

The early coastal settlers of the 1600s survived by fishing and trading furs with the Indians. White people gradually moved inland, engaged in lumbering and agriculture, and clashed, inevitably, with the Indians. Indian attacks on white settlements began to take place in the late 1600s. In 1693 the French, claiming English territory, allied themselves temporarily with the natives. The white population grew, while the Indians' numbers were depleted and their settlements pushed inland (Starbird 1928). By the mid seventeenth century, Indian access to the coast had been cut (Soule 1975), and the remainder of the native population had migrated to Canada (Starbird 1928).

The region prospered during the early years of the new nation. Shipbuilding and shipping joined fishing, lumbering, and agriculture as major activities, while the fur trade declined. In the decades before the Civil War, sea trade and shipbuilding gained great prominence. Manufacturing grew along the rivers, and transportation routes were expanded (Myers 1974).

After the Civil War, economic growth declined. The opening of western lands and the development of ironclad ships brought about a decline of agriculture and shipbuilding (MSDO 1976). Lumbering, shipping, and fishing retained their importance, and textiles and paper manufacturing continued to develop. Coastal communities became popular as summer resorts for the urban well-to-do (Myers 1974). Trends established in the late 1800s have continued into the present century. The economy has diversified, as non-resource-based industries have entered the region.

Within the fuelwood harvest region there are numerous sites of historic value. Some of these are in urban or settled regions--homes and public buildings, for example. Others, however, are in rural settings and adjacent to wooded areas. Included are trails, bridges, forts, mills, homesteads, and battlegrounds. These historic resources are inventoried in such documents as the National Register of Historic Places (NPS 1976).

Archaeologic Resources

Although man first occupied the fuelwood harvest region more than ten thousand years ago, few direct traces of this early culture have been found there. Some sites have recently been discovered along fossil drainage channels and beach features, however (Spiess 1978d). Evidence of later cultures has also been found. Gravesites and implements of the Moorehead Phase (Spiess 1978a), a cultural period dating from approximately 2,500 B.C. to 1,800 B.C., are lined in red ochre and have given people of this period the name "Red Paint People" (Soule 1975).

Generally speaking, however, most archaeologic sites of the harvest region can be classified under three headings: coastal shell middens, lithic sources, and campsites (Spiess 1978a). Shell middens occur as piles of clam and oyster shells left by

Indians on the coast along estuaries. Lithic sources are quarry sites where Indians found stone for making tools in the "talus slopes" below cliffs. Campsite remains occur in two areas: along inland waterways, especially at inlets and points where streams join, and on the fossil beaches of glacial lakes. These beaches are often one hundred feet higher than the lake bottom, due to postglacial lake drainage. Campsite remains consist of rock-lined campfires, chip stone, and at times, pottery (Spiess 1978a). Artifacts are normally found down to six inches beneath the mineral soil. Due to occasional pits and frost heaves, sites may be located at maximum depths of approximately eighteen inches (Spiess 1978b).

In general, archaelogical sites in the interior are not as conspicuous as they are along the coast. No easily visible structures, mounds, or earthworks give them away; rather, they must be discovered through careful search (Moorehead 1922).

Cultural Resources

The fuelwood harvest region has a range of cultural resources serving local communities and tourists. Museums, galleries, festivals and fairs, and dance and dramatic theaters are concentrated in and near the larger urban centers, such as Augusta, Lewiston-Auburn, and Greater Portland. They also are found near summer and winter resort regions along the coast, in the mountains, and near bodies of water (MSCAH 1977). Most towns of any size have their own libraries, as do the region's half-dozen colleges and universities (MSL 1977). These cultural centers are mostly located in developed, nonforested regions, near the populations they serve.

Aesthetic Resources

The fuelwood harvest region extends from the Maine coastline to the White Mountains and includes a variety of aesthetically valuable natural features and terrain. Along the jagged coast, the ocean meets a rocky, forested shore. Inland, the largely forested rolling hills and mountains are characterized by dispersed towns and agricultural settlements. The uneven terrain affords panoramic vistas of valleys and ridges. The region's

FIGURE 2.2.10-A: VIEW OF MT. CHOCORUA AND LAKE CHOCORUA IN CARROLL COUNTY, NEW HAMPSHIRE

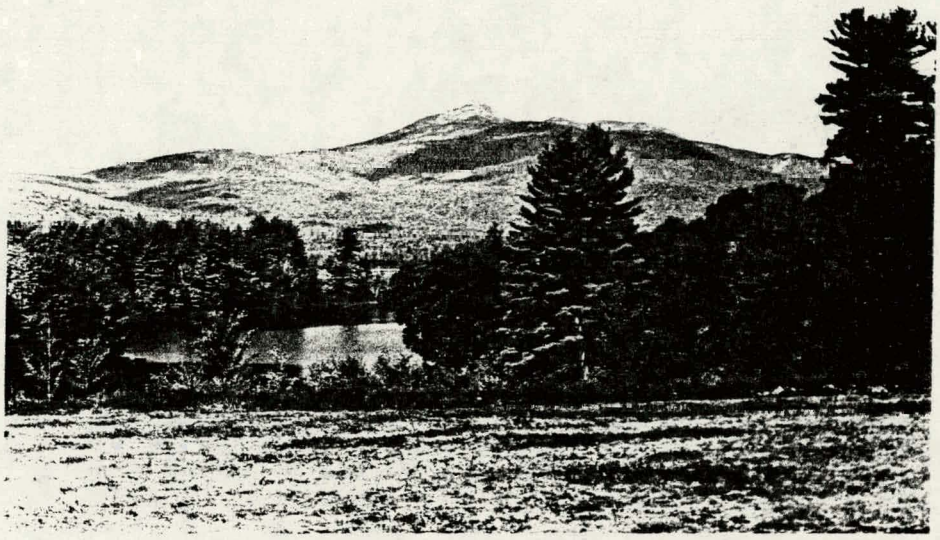
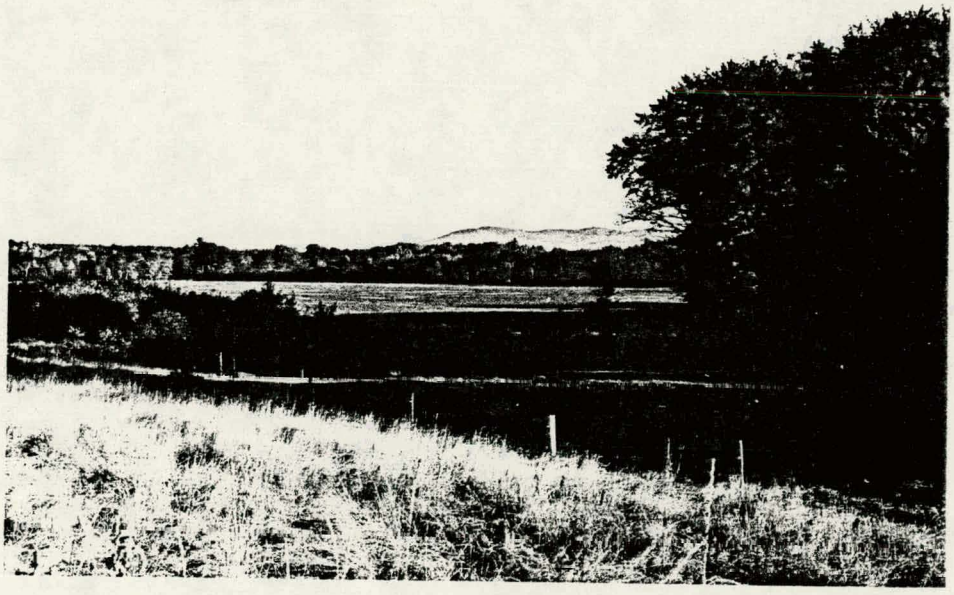


FIGURE 2.2.10-B: VIEW FROM A COUNTRY ROAD IN OXFORD COUNTY, MAINE



numerous lakes and streams offer scenic views, and such features as white water and mountain falls are distinctive. Agricultural lands add pastoral contrasts of pattern and color to a landscape predominantly unsettled and forested. Visual diversity is also created by seasonal changes such as autumnal foliage and winter snow covers. Figures 2.2.10-A and B demonstrate the variety of scenery found within the fuelwood harvest region.

Summer and winter tourists have long valued the fuelwood harvest region for its aesthetic qualities. Tourism continues to be a significant industry during all four seasons (MVTAC 1974) and seasonal home development remains popular (Hasbrouck 1978).

2.2.11 Transportation Systems

Railroads

The locations and ownership of rail lines in the harvest region are shown in Figure 2.2.11-A. The Maine Central Railroad is an important line for out-of-state as well as local traffic in Maine, and it is the only line serving Westbrook directly (MSDO 1977). The Portland Terminal Company manages local operations and maintenance of the railroad lines in the Westbrook area.

Roads

There are several different classifications of roads running through the harvesting region. They are: timber or forest roads; town roads or minor collectors; major collectors; minor arterials; and principal arterials. Forest roads are usually built to handle heavy truck traffic and may be paved, dirt, or gravel-surfaced. They are most often located on private property and are maintained by landowners (Noel 1978). Access from forest roads onto state highways is generally direct in Maine. In New Hampshire, however, access is often indirect, requiring trucks to travel on minor collectors (roads serving local traffic in small towns) before reaching major collectors (roads serving both local and through traffic) (Noel 1978). Major collectors feed into minor arterials, which in turn feed into principal arterials--those roads generally supporting heaviest traffic volumes in a

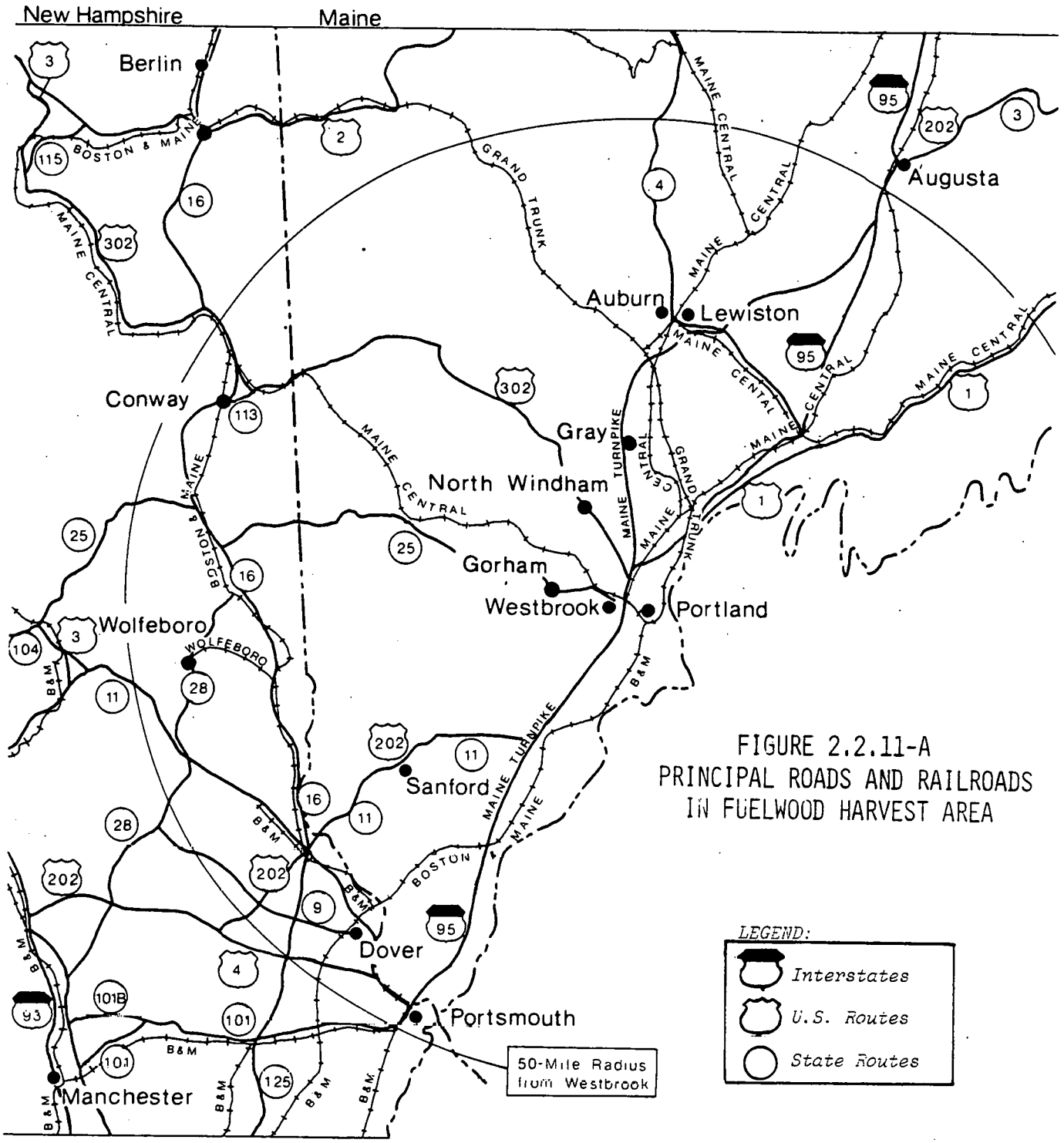


FIGURE 2.2.11-A
PRINCIPAL ROADS AND RAILROADS
IN FUELWOOD HARVEST AREA

Sources: NHDPW 1973; MDOT 1975.

state (Woodbury 1978). The principal arterials of the fuelwood harvest region are shown in Figure 2.2.11-A.

Traffic patterns. Two-way average annual daily traffic counts for various locations within the harvesting region are given in Appendix F. As might be expected, the counts show that the interstate systems and the Maine Turnpike, in general, support the highest traffic volumes in the region.

Existing truck traffic. Vehicle classification studies yield data on truck traffic as a percentage of total traffic for the primary and secondary arterials in the fuelwood harvest region. These percentages are shown for various locations on the principal arterials in Table 2.2.11-A. An average of all Maine and New Hampshire data shows that trucks compose approximately 25 percent of total traffic on these arterials within the harvesting region.

Road surface conditions. Highway sufficiency ratings are developed and used by the state departments of transportation in cooperation with the Federal Highway Administration. Improvement and resurfacing projects are prioritized according to these ratings; those sections of highway receiving lowest ratings generally receive money for physical improvement first.

Table 2.2.11-B gives a mileage breakdown for different types of highways and the mileage of each in various sufficiency rating categories in both Maine and New Hampshire. Maine figures for 1976 show that 59.3 percent of total highway miles in Maine are rated 70 or above, and thus are judged to be in fair or better condition. Similarly, 42.9 percent of the New Hampshire highway mileage is rated as in fair or better condition. Data from state officials indicate that countywide percentages of miles in highway sufficiency rating categories closely parallel statewide percentages (MDOT 1976a; Woodbury 1978). Therefore, about 60 percent of the roads in the Maine portion of the harvest region, and about 43 percent of the roads in the New Hampshire portion, can be assumed to be in fair condition or better.

Bridge conditions. The bridges in the harvest region that carry heavy truck traffic are generally in good condition or

TABLE 2.2.11-A: TRUCK TRAFFIC AS A PERCENTAGE OF TOTAL TRAFFIC AT VARIOUS LOCATIONS IN MAINE AND NEW HAMPSHIRE

Town	% Trucks	Year Data Collected
MAINE		
Bridgton	25.3	1976
Dixfield	29.6	1976
Falmouth (I-295)	19.8	1976
Farmington	28.7	1977
Kittery (I-95)	20.5	1977
Lebanon	26.5	1976
Sidney	25.6	1976
Turner	27.6	1976
Yarmouth (I-95)	22.3	1976
NEW HAMPSHIRE		
Berlin	23.9	1977
Conway	17.7	1976
Gorham	25.8	1977
Laconia	10.0	1972
Meredith	21.3	1977
Ossipee	30.6	1976
Shelburne	24.1	1977

Sources: NHDPW 1972-1977; MDOT 1976b; Thomas 1978a.

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have bypasses nearby that allow for continuous flows of traffic during maintenance periods (Dutton 1978; Sirois 1978). Some of the bridges in northern New Hampshire are closed to truck traffic during the spring because of thaw and mud conditions. Bans on truck traffic because of frost heaves usually become effective in mid May and extend through mid June. Truckers are alerted to bridge closures by letter and through posted signs at bridge sites. The specific bridges involved vary from year to year (Dutton 1978).

Impact of current traffic. A number of towns in the fuelwood harvest region are currently suffering from traffic congestion. The towns believed to be affected most include Conway and Wolfeboro in New Hampshire, and Gorham, Gray, and North Windham in Maine (Lee & Rhodes 1978; Noel 1978). Table 2.2.11-C summarizes the existing problems in these towns. The problems in North Windham are presently being corrected and should be relieved within the next four to five years.

No studies have been completed to date on the levels of noise and air pollution generated by automotive vehicles in the harvest region. However, there have been no complaints filed about these factors in the area (Lee & Rhodes 1978; Thomas 1978a).

2.2.12 Recreation

Tourism is Maine's second most valuable industry; only the paper and allied products industries produce more income for the state (MBPR 1977). Over sixty million people live within a day's drive of Maine. Between September 1972 and August 1973, more than ten million tourists spent 22.5 million days in the state (MVTAC 1974). Over that period, they generated $458 million of business. The common activities and expenditures of tourists are summarized in Table 2.2.12-A. Tourists spend money not only on direct recreational expenses such as ski lift tickets, fishing licenses, and golfing fees, but also on food, lodging, sports equipment, camera film, and other goods and services. In 1978, Maine tour-

TABLE 2.2.11-C: TOWNS IN FUELWOOD HARVEST REGION SHOWING EFFECTS OF TRAFFIC CONGESTION

Town	Route(s)	Description of Area and Problem
Conway, NH	NH Rt 16	This heavily traveled route runs through the center of town. Congestion occurs throughout the year, but particularly so during summer months.
Wolfeboro, NH	NH Rt 28	Wolfeboro suffers from summer congestion.
Gorham, ME	Jct of ME Rts 25 & 4	Congestion is aggravated by the movement of 65 foot oil tankers. Bypass construction is being considered.
Gray, ME	ME Rt 26 & US Rt 202	A difficult turn off Rt 26 onto Rt 202 leads to periodic congestion. This problem is worst during summer months.
N. Windham, ME	US Rt 302	US Rt 302 is being expanded from a two-lane highway to a four-lane highway. Congestion results from this work, but the problem should disappear in four years when construction is completed.

Sources: Lee & Rhodes 1978; Noel 1978.

TABLE 2.2.12-A: CHARACTERISTICS OF MAINE TOURISTS, 1972-1973

Type of Activity	Portion of Total Tourist Days *(percent)*	Average Size of Party *(people)*	Average Length of Stay *(days)*	Expenditures Per Person Per Day *(dollars)*
Sightseeing	19.9	3.0	2.1	15.85
Fishing/Hunting	11.2	3.5	2.0	6.88
Business	10.9	1.6	1.8	20.86
Fresh Water Beaching	10.5	3.7	3.3	4.76
Salt Water Beaching	6.5	3.4	2.4	9.34
Fresh Water Boating	6.0	3.5	4.5	6.44
Camping	5.0	3.7	5.3	9.20
Snowmobiling	4.4	3.3	1.2	3.95
Salt Water Boating	3.8	3.2	5.4	7.67
Skiing	2.1	3.1	1.5	13.61
Convention	0.6	1.9	1.8	16.94
Other	19.1	2.6	3.2	13.06
All Tourists	100.0	2.9	2.2	11.51

Source: MVTAC 1974.

ists spent $377 million in the state and generated another $290 million of indirect income (Williams 1979). The harvest region includes the State's most heavily used recreation areas (notable exceptions are Baxter State Park, Acadia National Park, and the Moosehead Lake Region). Data describing statewide recreation therefore roughly characterize the harvest region as well.

It is natural that the forest environment and rural landscape that are important to the quality of life of Maine residents also attract vacationers. People visit Maine to enjoy the coast, the inland lakes and streams, and the farm areas, as well as the cultural attractions of population centers.

Hunting and fishing are major recreational activities, and forested areas provide habitat for game and nongame species. Many people enjoy watching wildlife. Forested watersheds provide streams and lakes for canoeing and other water-based recreation. Hiking, camping, cross-country skiing, and other backcountry activities depend on the forest environment for solitude, natural beauty, shade, and shelter. Sightseeing, alpine skiing, picnicking, snowmobiling, and other recreational activities are enhanced by the forest environment. The colorful fall foliage gives rise to a surge of outdoor activity in autumn.

The opening of Interstate Route 95 and the Maine Turnpike improved access and precipitated a boom in second-home construction, particularly along waterfronts. A 1974 study found that 31 percent of the total rural population in Maine had primary residences elsewhere (Ragatz 1974). Conversion of these homes to year-round residences has caused concern for towns that must supply services, and for planning agencies concerned with uncontrolled growth. The tax rate increases and rising land values caused by second home development are a factor in the abandonment of farmland and forest management; public purchase of expensive land for recreation or protection has become infeasible in some areas (Payne, Gannon & Irland 1975). In addition, the congestion caused by tourists in popular recreation spots has caused resentment among Maine residents.

The Maine Statewide Comprehensive Outdoor Recreation Plan provides a detailed analysis of available recreational facilities in the state and outlines deficiencies in recreational opportunities. Federal, state, local, and private facilities are included. The Plan sets priorities for the state in recreational development (MBPR 1977).

The future of recreation and tourism in Maine and throughout the nation will be influenced by the price of gasoline, the level of discretionary income, and the changing age structure of the population. The Plan speculates that: energy constraints will lead to an increased demand for recreation areas near urban centers; year-round, destination resorts with a full spectrum of recreational facilities will become more popular; and seasonal recreational homes will be converted to year-round homes (MBPR 1977). While travel may decline overall, travel to and within Maine may stabilize or even increase as a result of its proximity to large population centers. Any reduction in discretionary income may bring about a substitution of home- or community-centered recreation for travel and tourism (Marcin & Lime 1977).

Changes in the age structure of the population and in family structure and the declining growth in population will influence the types of recreational opportunities in demand (Marcin & Lime 1977). For example, the great demand for backcountry recreation and alpine ski areas may decline as the children of the post-World War II baby boom reach their middle years and demand other recreational opportunities.

2.3 PROJECTED ENVIRONMENTAL SETTING WITHOUT PROJECT

2.3.1 Projected Demographic Growth

The population of both the Portland metropolitan area and the fuelwood harvest region is expected to continue the growth trend of the 1970s into the early 1980s. Total population in the ten counties (seven in Maine and three in New Hampshire) should reach almost 800,000 by 1980 (MSPO 1977; NHOCP 1978). The net increases in the region since 1970 have been due to net immigration rather than to increasing birth rates. Because the price of petroleum products is projected to triple by 2000, a trend that will be strongly felt by 1985 (Naill & Backus 1977), migration to areas with relatively dispersed populations, such as Maine and New Hampshire, is likely to decrease. This means that by the mid 1980s, growth can be expected to lessen.

The population of major cities in the area has declined over the past decade as that of the suburbs has grown. This trend may continue; however, it is also possible that by the mid 1980s the major cities may start to experience another population spurt. Renovation of the downtown areas may attract people back to the city, so that they can enjoy both the cultural advantages and lower commuting costs.

2.3.2 Projected Economic Growth

The economy of the area has grown quickly in the past two years, after a recovery period following the 1973 recession. This trend toward high growth, as measured by general economic activity and employment by sector, should continue into the early 1980s. Trade and services, which comprise more than 50 percent of the area's jobs, are expected to continue to enlarge as the tourist industry expands and the region's population continues to grow (MDMA 1977). In the manufacturing sector, production of nonelectrical machinery is expected to increase over the next ten years (MDMA 1978a; NHDES 1978a). Production of food and

kindred products, activities that are becoming more capital-intensive, may see declines in employment (MDMA 1977). The agricultural sector should remain stable; transportation, public utilities, finance, insurance, and real estate, as well as public administration, should show modest gains (MDMA 1977; NHDES 1978a).

In the mid 1980s, economic growth in the region may slow down in response to projected rising petroleum prices (Naill & Backus 1977). If gasoline, home heating oil, and other petroleum-based products become more expensive, regional economic activity is likely to contract. These fuels are already significantly more expensive in New England than in other regions of the country (BNL 1976).

2.3.3 Projected Land Use Change

Future Land Use in Plant Site Region

Greater Portland metropolitan area. In the early 1970s, Greater Portland experienced an economic boom that resulted in the development of many acres of vacant and agricultural lands surrounding the urban core. In the past two years this trend has tapered off into a stable, low-growth situation (Eyerman 1978). According to a 1977 Portland Area Comprehensive Transportation Study (PACTS) survey, 110,356 of the region's remaining vacant acres are developable (PACTS 1977). A 1978 PACTS land use projection has estimated total 1975 to 1990 demand to be approximately 10,000 acres or 10 percent of available lands. Most of this demand is residential, expansion being expected to occur primarily in the large, peripheral townships of Gorham, Windham, and Scarborough. Commercial and industrial growth is expected to remain concentrated in Portland, South Portland, and Scarborough (PACTS 1978). Agricultural land use will probably stabilize due to changing public attitudes and increased transportation costs (GPCOG 1977b). Table 2.3.3-A displays GPCOG's current estimates of land development in the area between 1975 and 1990.

TABLE 2.3.3-A: GREATER PORTLAND LAND USE PROJECTIONS - 1975 TO 1990 INCREMENT

(acres)

Community	Residential	Industrial	Commercial
Westbrook	319	8[2]	12[3]
Cape Elizabeth	870[1]	0	1
Cumberland	890[1]	4	5
Falmouth	NA	NA	NA
Gorham	1,637	7	16
Portland	339	22	57[4]
Scarborough	1,612	22	31[5]
South Portland	309	20	41
Windham	1,623	2	12
Yarmouth	722[1]	2	6

NA - Not Available.
1. Projections of housing units, not acres.
2. Alternatives: 7 acres; 9 acres.
3. Alternative: 17 acres.
4. Alternatives: 68 acres; 76 acres.
5. Alternative: 50 acres.

Source: PACTS 1978.

Central Maine Power Company plans no new generating facilities for the Greater Portland area, although the region's growth will necessitate transmission line extensions and substation construction for transmission of power into the area from other Maine and New England generating stations (Mathews 1978b). These transmission lines and substations will require development of additional land in the region.

Westbrook. Of Westbrook's total land area, 6,761 acres or 63 percent were vacant and developable in 1977 (PACTS 1977). The city's greatest land demands to the year 1990, like those of the entire Portland area, will be residential (PACTS 1977). Residential development, projected at 319 acres, will take place primarily in the more rural northern and southern portions of the city (PACTS 1978). However, as Westbrook is located relatively near to downtown Portland, the more important trend will be one towards rehabilitation and conversion of single-family and other structures into multi-family residences in the densely populated central portion of the city (Eyerman 1978).

Industrial development, projected to be eight additional acres by 1990 (PACTS 1978), will most likely occur near the Westbrook Arterial and in the south, at outer Spring Street or in the Five Star Industrial Park. The older mills and machine shops along the Presumpscot in downtown Westbrook may also be replaced (Eyerman 1978). Commercial growth, estimated at twelve acres, will be concentrated in the south (PACTS 1978), in the Brighton Avenue/Exit 8 region on the Portland boundary, and along Bridgton Street, a northerly tourist route (Eyerman 1978). Table 2.3.3-B shows the projection of land use expansion for Westbrook between 1975 and 1990.

Thus, in review, most development to the year 1990 will occur in eastern and southern Westbrook. Land use in the central downtown environs will intensify, whereas the northern portion of the city will be conserved largely as rural and agricultural land.

Future Land Use in the Fuelwood Harvest Region

The rising cost of energy will profoundly influence land use in the plant's fuelwood harvest region over the next twenty

TABLE 2.3.3-B: WESTBROOK LAND USE PROJECTIONS - 1975-1990 INCREMENT

(acres)

Land Use Category	Area
Single-family residential	215
Multi-family residential	104
Industrial	8[1]
Trades	8
Services	4[2]

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1. Alternatives: 7 acres; 9 acres.
2. Alternative: 6 acres.

Source: PACTS 1978.

years. The past trend toward suburbanization depended on cheap energy for automobiles (Androscoggin 1978) and for the heating of single-family homes and large, one-story commercial buildings. Commercial and industrial growth will continue to show this pattern of limited decentralization; however, the unanswered question is whether higher energy costs will restrict new residential growth to areas already developed (GPCOG 1977b). In addition, higher energy costs may force some industries, which already pay energy prices higher than those in other regions, to leave the state (BNL 1976).

Although the trend toward smaller households (fewer people per living unit) will increase the demand for land more than population growth alone would indicate (Androscoggin 1978) the increased costs of home ownership may balance this trend by making cluster and multi-unit housing more economically attractive (GPCOG 1977b). These housing units consume less land per unit than single-family dwellings.

The effects of higher energy costs on tourism are uncertain. The Bureau of Parks and Recreation (MBPR 1977) predicts that people will travel shorter distances to fewer locations for longer periods. Since the harvesting region is within one day's drive of sixty million people, tourism will continue to be an important influence on land use (MVTAC 1974).

Forests will continue to dominate the region. Increased demand for wood, both as a fuel and as a substitute for more energy-intensive structural materials, may result in more efficient and profitable multiple-use forest management, or it could lead to extraction without regard for wildlife, future productivity, and recreational uses.

Development pressures on farmland, particularly in urban and coastal areas, will undoubtedly continue. However, the rate of farmland loss in the bulk of the fuelwood harvest region seems to have leveled off; the effects of open space taxation and awakening public concern over development of agricultural land are still undocumented. The costs of transporting food from distant agricultural centers may improve the economics of farming in the

Northeast and hence may help preserve farmland. On the other hand, the costs of petroleum-derived fertilizer could slow or offset the trend toward local agricultural production (GPCOG 1977b).

In short, rapidly escalating energy costs render past land use trends obsolete for predicting changes that will occur over the next two decades. Current analyses indicate, however, that this influence should slow trends toward suburbanization and ruralization and strengthen growth in areas already more intensively developed.

2.4 REFERENCES

ACE 1977 — U.S. Army Corps of Engineers. Environmental Impact Statement, Dickey-Lincoln School Lakes: Appendix E - Aquatic Ecosystem and Fisheries Studies, ACE, Waltham, MA (1977).

Anderson & Strunk 1973 — Anderson, B.R., and Strunk, J.M. Great Ponds in Maine, Maine State Planning Office, Augusta, ME (September 1973).

Androscoggin 1978 — Androscoggin Valley Regional Planning Commission. Comprehensive Planning Assistance Program: Land Use Element, AVRPC, Auburn, ME (February 1978).

Armson 1977 — Armson, K.A. Forest Soils: Properties and Processes (Toronto: University of Toronto, 1977).

Barton 1978 — Barton, William, Federal Bureau of Mines, Newmarket, NH. Telephone conversation (August 16, 1978).

BNL 1976 — Brainard, Joel P.; Munson, James S.; and Palmedo, Philip F. The Energy Situation in New England, #BNL 50580, Brookhaven National Laboratory, Upton, NY (November 1976).

Bragdon 1970 — Bradgon, Clifford R. Noise Pollution - The Unquiet Crisis (Philadelphia: University of Pennsylvania Press, 1970).

Brooks & Deevey 1966 — Brooks, J.L., and Deevey, E.S., Jr. "New England," in Limnology in North America, D.G. Frey, ed. (Madison: University of Wisconsin Press, 1966).

Census 1960 — U. S. Department of Commerce, Bureau of the Census. Characteristics of the Population - Maine, New Hampshire: 1960, USDC, Washington, DC (1960).

Census 1970 — U. S. Department of Commerce, Bureau of the Census. Characteristics of the Population - Maine, New Hampshire: 1970, USDC, Washington DC (1970).

Census 1976 — U. S. Department of Commerce, Bureau of the Census. Population Estimates - Maine, New Hampshire, USDC, Washington, DC (1976).

Census 1977 — U. S. Department of Commerce, Bureau of the Census. Current Population Report, Series P-25, Number 667, USDC, Washington, DC (May 1977).

Cleaves 1978 — Cleaves, Robert E. The Maine Location for Your Plant, Area Development Council of Maine, Augusta, ME (1978).

CMP 1977 — Central Maine Power Company. CMP Supervisor's Manual - Facts About the Company as of 12/31/76, CMP, Augusta, ME (1977).

CMP 1978 — Central Maine Power Company. "Map of Greater Portland Power Transmission System," on file at CMP, Portland, ME (1978).

Coffman & von Hake 1972 — Coffman, Jerry L., and von Hake, Carl A., eds. Earthquake History of the United States, U. S. Department of Commerce, Washington, DC (1972).

Connor 1976 — Connor, James. "Landforms of the State of Maine," map, Maine Land Use Regulation Commission, Augusta, ME (1976).

Corvetti 1978 — Corvetti, David, Assistant to the Chief, Mechanical Office, Maine Central Railroad, Portland, ME. Telephone conversation (September 6, 1978).

Cowardin, Golet & LaRoe 1977 — Cowardin, L.M.; Golet, F.C.; and LaRoe, E.T. Classification of Wetlands and Deep-water Habitats of the United States (An Operational Draft), U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC (October 1977).

Crawford 1978 — Crawford, Ed, Traffic Manager, S.D. Warren Company, Westbrook, ME. Meeting (July 25, 1978).

Crawford & Orach 1978 — Crawford, Ed, Traffic Manager, and Orach, Steve, Woodlands Manager, S. D. Warren Company, Westbrook, ME. Meeting (July 25, 1978).

Davis 1966 — Davis, R.B. "Spruce-fir Forests of the Coast of Maine," Ecological Monographs 36 (1966).

Dibner 1972 — Dibner, Martin, ed. Portland, Greater Portland Landmarks, Inc., Portland, ME (1972).

Donahue 1978 — Donahue, Michael P., Maine Department of Manpower Affairs, Augusta, ME. Telephone conversation (August 8, 1978).

Donahue 1979 — Donahue, Michael P., Maine Department of Manpower Affairs, Augusta, ME. Telephone conversation (March 21, 1979).

Doyle 1967 — Doyle, Robert G. "Preliminary Geologic Map of Maine," Maine Geological Survey, Augusta, ME (1967).

Dutton 1978 — Dutton, Robert, Administrative Assistant, Road Maintenance Division, New Hampshire Department of Public Works and Highways, Concord, NH. Meeting (August 17, 1978).

Eastman 1977 — Eastman, L.M. "Small Whorled Pogonia, Isotaria medeoloides (Pursh) Raf., in Maine, and its Relevance to the Critical Areas Program," Maine Critical Areas Program, State Planning Office, Augusta, ME (1977).

EPA 1978 — U.S. Evironmental Protection Agency. 1977 Annual Report on Air Quality in New England, EPA, Region I, Lexington, MA (1978).

EPA 1979 — U.S. Environmental Protection Agency. "National Aerometric Data Bank: Yearly Frequency Distribution: State (20): Maine," EPA, Research Triangle Park, NC (1979).

Eyerman 1978 — Eyerman, Mark, Senior Planner, Greater Portland Council of Governments, Portland, ME. Meeting (July 27, 1978).

FBI 1976 — U. S. Justice Department, Federal Bureau of Investigation. Crime in the United States, USJD, Washington DC (1976).

Ferguson & Kingsley 1972 — Ferguson, Roland H., and Kingsley, Neal P. The Timber Resources of Maine, Forest Service Resource Bulletin NE-26, U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1972).

Forcier 1975 — Forcier, L.K. "Reproductive Strategies and the Co-occurrence of Climax Species," Science 189 (1975).

FR 1979 — Federal Register, vol.44, no. 28 (February 8, 1979).

FRG 1978 — New Hampshire Forest Resources Group. Forests and Forestry in New Hampshire, Society for the Protection of New Hampshire Forests, Concord, NH (1978).

Goldthwait 1950 — Goldthwait, James W., et al. "Surficial Geology of New Hampshire," map, New Hampshire State Planning and Development Commission, Concord, NH (1950).

Goldthwait 1969 — Goldthwait, James W., The Geology of New Hampshire - Part 1: Surficial Geology, New Hampshire Department of Resources and Economic Development, Concord, NH (1969).

Gorrill 1962 — Gorrill, William, R., Consulting Engineer. Subsurface Investigation for Proposed #14 Machine Room Addition, S.D. Warren Co., Cumberland Mills, Maine, report done under contract to S.D. Warren Company (April 11, 1978).

Gorrill 1969 — Jordan Gorrill Associates, Consulting Soil Engineers. Subsurface Investigation - Proposed Package Boiler, done under contract to S.D. Warren Company (October 23, 1969).

Gorrill 1975 — Jordan Gorrill Associates, Consulting Soil Engineers. Subsurface Investigation - Stability of On-Site Sludge Dump, report done under contract to S.D. Warren Company (May 9, 1975).

GPCC 1978 — Greater Portland Chamber of Commerce. Greater Portland, no. 23 GPCC, Portland, ME. (July 1978).

GPCOG 1975 — Greater Portland Council of Governments. "Land Use Map of City of Westbrook," on file at GPCOG, Portland, ME (1975).

GPCOG 1977a — Greater Portland Council of Governments. Greater Portland Overall Economic Development Program - 1977, GPCOG, Portland, ME (1977).

GPCOG 1977b — Greater Portland Council of Governments. Greater Portland Area: Past Trends and Future Projections in Population, Housing, Employment, and Land Use, GPCOG, Portland, ME (November 1977).

Gramlich 1979 — Gramlich, F., Wildlife Biologist, U.S. Fish and Wildlife Service, Augusta, ME. Telephone conversation (March 29, 1979).

Gray 1973 — Gray, Donald M., ed. Handbook on the Principles of Hydrology, Water Information Center, Inc., Port Washington, NY (1973).

Hadley & Devine 1974 — Hadley, Jarvis B., and Devine, James F. "Seismotectonic Map of the United States," U.S. Geological Survey, Washington, DC (1974).

Hammond 1964 — Hammond, Edwin H. "Classes of Land-Surface Form in the Forty-eight States, U.S.A.," Map Supplement #4, Association of American Geographers, vol. 54, no. 1 (March 1964).

Hasbrouck 1978 — Hasbrouck, Sherman. Indicators of Housing in Maine 1977: A Report on Housing Trends, Cooperative Extension Service and Environmental Studies Center, University of Maine, Orono, ME (1978).

Hayes 1966 — Hayes, G.S. "Surface-water Resources of Maine," Maine Water Utilities Association Journal, vol 42, no. 1 (1966).

Holzworth 1972 — Holzworth, George C. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States, AP-101, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC (January 1972).

Hovland 1978 — Hovland, Bruce, Forester, Society for the Protection of New Hampshire Forests, Concord, NH. Meeting (August 7, 1978).

Hussey 1971 — Hussey, Arthur M. "Geologic Map of the Portland Quadrangle, Maine," Maine Geological Survey, Augusta, ME (1971).

Hutchinson & Spencer 1975 — Hutchinson, A., and Spencer, H., Jr. An Appraisal of the Fishery and Wildlife Resources of the Greater Portland Regional Planning Unit, Coastal Planning Group, State Planning Office, Augusta, ME (January 1975).

Johnson 1974 — Johnson, Richard T. Ambient Noise Testing, 1971-1974, Environmental Improvement Report No. 306, S.D. Warren Co., Westbrook, ME (1974).

Johnson 1978 — Johnson, Richard T. "Unofficial summary of ambient SO_2 data, 1973-1977," Environmental Improvement Department, S.D. Warren Co., Westbrook, ME (1978).

Kingsley 1976 — Kingsley, Neal P. The Forest Resources of New Hampshire, Resource Bulletin NE-43, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1976).

Kingsley & Birch 1977 — Kingsley, Neal P., and Birch, T.W. The Forest Landowners of New Hampshire and Vermont, Forest Resource Bulletin NE-51, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1977).

Labrecque 1978 — Labrecque, Richard, Director of Environmental Improvement, S.D. Warren Co., Westbrook, ME. Meeting (July 25, 1978).

Labrecque 1979 — Labrecque, Richard, Director of Environmental Improvement, S.D. Warren Co., Westbrook, ME. Telephone conversation (March 16, 1979).

Lautzenheiser 1972 — Lautzenheiser, Robert E. "Climate of Maine," in Climates of the States, National Oceanic and Atmospheric Administration, Silver Spring, MD (1972).

Lee & Rhodes 1978 — Lee, Robert M., Traffic Research Engineer, and Rhodes, Don, Engineering Assistant, Planning and Economics Division, New Hampshire Department of Public Works and Highways, Concord, NH. Meeting (August 17, 1978).

Lewis 1968 — Lewis, John R. An Early History of Pride's Corner, The Men's Club of the Pride's Corner Congregational Church, Westbrook, ME (1968).

Libby 1978a — Libby, Robert A., City Assessor's Office, Westbrook, ME. Meeting (July 13, 1978).

Libby 1978b — Libby, Robert A., City Assessor's Office, Westbrook, ME. Meeting (August 18, 1978).

Likens et al. 1971 — Likens, G.E.; Borman, F.H.; Pierce, P.S.; and Fisher, D.W. "Nutrient-Hydrologic Cycle Interaction in Small Forested Watershed Ecosystems," in P. Duvigneaud, ed. Proceedings of the Brussels Symposium on Productivity of Forest Ecosystems (Paris: UNESCO, 1971).

Ludlum 1976 — Ludlum, David, and Editors of Blair and Ketchum's Country Journal. New England Weather Book (Boston: Houghton Mifflin Co., 1976).

Lull & Reinhart 1972 — Lull, Howard W., and Reinhart, Kenneth G. Forests and Floods in the Eastern United States, Research Paper NE-226, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1972).

Lyons 1978 — Lyons, John B., Professor of Mineralogy and Geology, Dartmouth College, Hanover, NH. Telephone conversation (July 14, 1978).

Maitland 1978 — Maitland, P.S. Biology of Fresh Waters (New York: Halsted Press, 1978).

Marcin & Lime 1977 — Marcin, Thomas C., and Lime, David W. "Our Changing Population Structure: What Will It Mean for Future Outdoor Recreation Use?", in General Technical Report WO-2, Forest Products Laboratory, Madison, WI (March 1977).

Marks 1975 — Marks, P.L. "On the Relation between Extension Growth and Successional Status of Deciduous Trees of the Northeastern United States," Torry Botanical Club Bulletin 102, Department of Biological Sciences, State University College, Brockport, NY (1975).

Mathews 1978a — Mathews, Fred, Power Department, Central Maine Power Company, Portland, ME. Meeting (July 25, 1978).

Mathews 1978b — Mathews, Fred, Power Department, Central Maine Power company, Portland, ME. Telephone conversation (August 15, 1978).

Mathews 1978c — Mathews, Fred, Power Department, Central Maine Power Company, Portland, ME. Telephone conversation (August 17, 1978).

MBPR 1977 — Maine Bureau of Parks and Recreation. Maine State Comprehensive Outdooor Recreation Plan, MBPR, Augusta, ME (1977).

MBWQC 1977 — Maine Department of Environmental Protection, Bureau of Water Quality Control. Maine Water Quality Status, MDEP, Augusta, ME (1977).

MBWQC-A 1975 — Maine Department of Environmental Protection, Bureau of Water Quality Control. Androscoggin River Basin Water Quality Management Plan, MBWQC, Augusta, ME (1975).

MBWQC-K 1976 — Maine Department of Environmental Protection, Bureau of Water Quality Control. Kennebec River Basin Water Quality Management Plan, MBWQC, Augusta, ME (1976).

MBWQC-MC 1976 — Maine Department of Environmental Protection, Bureau of Water Qualtiy Control. Maine Coastal Basin Water Quality Management Plan, MBWQC, Augusta, ME (1976).

MBWQC-P 1976 — Maine Department of Environmental Protection, Bureau of Water Quality Control. Presumpscot River Basin - Cumberland County Tidewater Water Quality Management Plan, MDEP, Augusta, ME (1976).

MBWQC-SM 1976 — Maine Department of Environmental Protection, Bureau of Water Quality Control. Southern Maine River Basins Water Quality Management Plan, MBWQC, Augusta, ME (1976).

McKinnon, Hyde, & Cline 1935 — McKinnon, F.S.; Hyde, G.R.; and Cline, A.C. "Cut-over Field Pine Lands in Central New England," Harvard Forest Bulletin, no. 18, Petersham, MA (1935).

MDC undated — Maine Department of Conservation. List of logging firms in Maine by county, on file at MDC, Augusta, ME (undated).

MDECS 1977a — Maine Department of Educational and Cultural Services. Maine Educational Facts 1976-1977, MDECS, Augusta, ME (1977).

MDECS 1977b — Maine Department of Educational and Cultural Services. Maine Educational Directory, MDECS, Augusta, ME (1977).

MDEP 1977, 1978 — Maine Department of Environmental Protection. "SAROAD Hourly Data Form, Ozone Observations for Bridgton, Cape Elizabeth, and Grey," MDEP, Augusta, ME (1977, 1978).

MDEP 1979 — Maine Department of Environmental Protection. State Implementation Plan for Air Quality, draft proposed revision, MDEP, Augusta, ME (January 1979).

MDHS 1972-1978 — Maine Department of Human Services, Division of Health Engineering. "Public Water Supply: Annual Summary" and "Water Utility Survey" by utility, data from 1972 to 1978 on file at MDGS, Augusta, ME.

MDMA 1978a — Maine Department of Manpower Affairs. Annual Planning Report Of Cumberland County: Fiscal 1978, MDMA, Augusta, ME (1978).

MDMA 1978b — Maine Department of Manpower Affairs. Maine Manpower, MDMA, Augusta, ME (June 1978).

MDMA 1978c — Maine Department of Manpower Affairs. Annual Planning Report: Fiscal 1978 Balance of State, MDMA, Augusta, ME (1978).

MDMA 1978d — Maine Department of Manpower Affairs. Annual Planning Report of Kennebec County: Fiscal 1978, MDMA, Augusta, ME (1978).

MDOT 1975 — Maine Department of Transportation Bureau of Planning. "State of Maine Traffic Flow Map: 1974 Average Daily Traffic," MDOT, Augusta, ME (1975).

MDOT 1976a — Maine Department of Transportation. Highway Sufficiency Rating Report, MDOT, Augusta, ME (1976).

MDOT 1976b — Maine Department of Transportation. "Classification of Vehicles," unpublished reports, MDOT, Augusta ME (1976).

Miller 1977 — Miller, David. Water at the Surface of the Earth (New York: Academic Press, 1977).

Moorehead 1922 — Moorehead, Warren K. A Report on the Archaeology of Maine. Department of Archaeology, Phillips Academy, Andover, MA (1922).

MSCAH 1977 — Maine State Commission on the Arts and Humanities. Maine Cultural Organizations, MSCAH, Augusta, ME (1977).

MSDO 1976 — Maine State Development Office, Maine Marketing Directory, MSDO, Augusta, ME (1976).

MSDO 1977 — Maine State Development Office. Facts about Industrial Maine, MSDO, Augusta, ME (1977).

MSL 1977 — Maine State Library. Libraries of Maine: Directory and Statistics 1976, MSL, Department of Education and Cultural Services, Augusta, ME (1977).

MSPO 1977 — Maine State Planning Office. Population Projection Series PPS-2, MSPO, Augusta, ME (August 1977).

MSPO 1978 — Maine State Planning Office. Growth Management in Maine, MSPO, Augusta, ME (April 1978).

MVTAC 1974 — Maine Vacation Travel Analysis Committee. Tourism in Maine: Summary Report, Maine Department of Commerce, Augusta, ME (June 1974).

Myers 1974 — Myers, Denys Peter. "The Historic Architecture of Maine," Maine Catalog, Maine State Museum, Augusta, ME (1974).

Naill & Backus 1977 — Naill, Roger, and Backus, George. FOSSIL1: Evaluation of the National Energy Plan, Resource Policy Center, Thayer School of Engineering, Dartmouth College, Hanover, NH (1977).

NHDE 1978 — New Hampshire Department of Education. Tuition Liabilities and Per Pupil Costs, NHDE, Concord, NH (1978).

NHDES 1978a — New Hampshire Department of Employment Security. Employment by Occupation to 1978, NHDES, Concord, NH (April 1978).

NHDES 1978b — New Hampshire Department of Employment Security. Employment and Unemployment, NHDES, Concord, NH (June 1978).

NHDPW 1973 — New Hampshire Department of Public Works and Highways, Planning and Economics Division. "State of New Hampshire Traffic Flow Map: 1972 Traffic," NHDPW, Concord, NH (1973).

NHDPW 1972-1977 — New Hampshire Department of Public Works and Highways, Planning and Economics Division. Motor vehicle classification reports, data from 1972 to 1977 on file at NHDPW, Concord, NH.

NHOCP 1978 — New Hampshire Office of Comprehensive Planning. Estimates of Year-Round Housing Units in New Hampshire, NHOCP, Concord, NH (1978).

NHWSPCC 1977 — New Hampshire Water Supply and Pollution Control Commission. Public Water Supplies 1974-1976, NHWSPCC, Concord, NH (1977).

NHWSPCC-P 1975 — New Hampshire Water Supply and Pollution Control Commission. Piscataqua River and Coastal New Hampshire Basins Water Quality Management Plan, Staff Report No. 67, NHWSPCC, Concord, NH (1975).

NHWSPCC-S 1975 — New Hampshire Water Supply and Pollution Control Commission. Saco River Basin Water Quality Management Plan, Staff Report No. 69, NHWSPCC, Concord, NH (1975).

Nickerson 1978 — Nickerson, Paul, Senior Staff Specialist, U.S. Fish and Wildlife Service, Newton Corners, MA. Personal communication (1978).

NOAA 1977 — National Oceanic and Atmospheric Administration, National Climatic Center. Climatological Data Annual Summary -- New England, 1977, vol. 89, no. 13, NCC, Asheville, NC (1977).

NOAA 1978 — National Oceanic and Atmospheric Administration, National Climate Center. "Wind Distribution by Pasquill Stability Classes (6) STAR Program for Portland, Maine," Job No. 52888, NOAA, Asheville, NC (1978).

Noel 1978 — Noel, Rene, District Forester, Southern Region, Forest Management Division, Maine Bureau of Forestry, Augusta, ME. Personal communication (1978).

NPS 1976 — U. S. Department of the Interior, National Park Service. The National Register of Historic Places 1976, USDI, Washington, DC (1976).

Odum 1971 — Odum, Eugene P. Fundamentals of Ecology, 3rd ed. (Philadelphia: W.B. Saunders Co., 1971).

PACTS 1977 — Portland Area Comprehensive Transportation Study. 1977 land use acreage summary sheets on file at Maine Department of Transportation, Augusta, ME (1977).

PACTS 1978 — Portland Area Comprehensive Transportation Study. 1975-1990 Land Use Projections, PACTS Major Update Study, Maine Department of Transportation, Augusta, ME (1978).

Parks 1978 — Parks, Harold, Administrative Assistant, City of Westbrook, ME. Meeting (June 27, 1978).

Payne, Gannon & Irland 1975 — Payne, Brian; Gannon, Richard; and Irland, Lloyd. The Second Home Recreation Market in the Northeast, Bureau of Outdoor Recreation, U.S. Department of the Interior, Washington, DC (1975).

Prescott 1976 — Prescott, Glenn C., Jr. Maine Basic Data Report No. 9: Groundwater Series: Windham-Freeport-Portland Area, open file report, U.S. Geological Survey office, Augusta, ME (1976).

Prescott 1977 — Prescott, Glenn C., Jr. "Groundwater Favorability and Surficial Geology of the Windham-Freeport Area, Maine," map, U.S. Geological Survey Hydrological Investigations Atlas HA-564, USGS, Washington, DC (1977).

Ragatz 1974 — Ragatz, Richard. Recreational Properties: An Analysis of the Market for Privately Owned Recreational Lots and Leisure Homes, Richard L. Ragatz Assoc., Inc., Eugene, OR (1974).

Reidman 1978 — Reidman, Ed, City Engineer, Westbrook, ME. Meeting (July 10, 1978).

Reidman et al. 1978 — Reidman, Ed, Westbrook City Engineer; O'Gara, William B., Mayor of Westbrook; Parks, Harold, Assistant to Mayor, Westbrook, ME. Meeting (July 10, 1978).

Rigney 1979 — Rigney, Joseph, Chief Meteorologist, National Weather Service, Portland, ME. Telephone conversation (February 1, 1979).

Rolfe 1978 — Rolfe, David, Plant Manager, S.D. Warren Co., Westbrook, ME. Meeting (July 25, 1978).

Rowe 1952 — Rowe, Ernest R., et al. Highlights of Westbrook History, Marian B. Rowe, ed., Westbrook Women's Club, Westbrook, ME (1952).

Scarola 1973 — Scarola, J.F. Freshwater Fishes of New Hampshire, N.H. Fish and Game Department, Division of Inland and Marine Fisheries, Concord, NH (1973).

SCS 1952 — U.S. Department of Agriculture, Soil Conservation Service. Soil Survey of York County, Maine (Washington: U.S. Government Printing Office, 1952).

SCS 1968 — U.S. Department of Agriculture, Soil Conservation Service. Soil Survey: Belknap County, New Hampshire (Washington: U.S. Government Printing Office, 1968).

SCS 1970 — U.S. Department of Agriculture, Soil Conservation Service. Soil Survey of Androscoggin and Sagadahoc Counties, Maine (Washington: U.S. Government Printing Office, 1970).

SCS 1973 — U.S. Department of Agriculture, Soil Conservation Service. Soil Survey of Strafford County, New Hampshire (Washington: U.S. Government Printing Office, 1973).

SCS 1974 — U.S. Department of Agriculture, Soil Conservation Service. Soil Survey: Cumberland County, Maine (Washington: U.S. Goverment Printing Office, 1974).

SCS 1975 — U.S. Department of Agriculture, Soil Conservation Service. Soil Taxonomy, Agriculture Handbook, no. 436 (Washington: U.S. Government Printing Office, 1975).

SCS 1977a — U.S. Department of Agriculture, Soil Conservation Service. Soil Survey of Carroll County, New Hampshire (Washington: U.S. Government Printing Office, 1977).

SCS 1977b — U.S. Department of Agriculture, Soil Conservation Service. State-wide Set of Brief Soil Descriptions - Maine, Agriculture Experiment Station, Orono, ME (1977).

SCS 1978 — U.S. Department of Agriculture, Soil Conservation Service. Soil Survey of Kennebec County, Maine (Washington: U.S. Government Printing Office, 1978).

SCS-ME 1970 — U.S. Department of Agriculture, Soil Conservation Service. Conservation Needs Inventory, Maine, published jointly by SCS and Maine Agricultural Experiment Station, Orono, ME (1970).

SCS-NH 1970 — U.S. Department of Agriculture, Soil Conservation Service. New Hampshire Soil and Water Conservation Needs Inventory, SCS, Durham, NH (1970).

Sewall 1978 — James W. Sewall Company. Preliminary Biomass and Volume Estimates for Westbrook Study Area 1978, James W. Sewall Co., Old Town, ME (1978).

S.D. Warren 1973 — S.D. Warren Company. "S.D. Warren Company - Today and Yesterday," Warren's Standard, Special Edition (September 1973).

S.D. Warren 1975 — S.D. Warren Company. "Cumberland Mills Houses Called Distinguished Architecture of 1800s," Warren's Standard (February 1975).

S.D. Warren 1976 — S.D. Warren Company, Environmental Improvement Department. "Summary of the River Project - 1976," report no. EIR #387, file no. 27-6011, unpublished (1976).

S.D. Warren 1977 — S.D. Warren Company, Environmental Improvement Department. "Summary of the River Project - 1977," report no. EIR #422, file no. 27-6011, unpublished (1977).

S.D. Warren 1978 — S.D. Warren Company, Environmental Improvement Department. "Summary of the River Project - 1978," report no. EIR #451, file no. 27-6011, unpublished (1978).

Shettleworth 1978 — Shettleworth, Earle G., State Historic Preservation Officer, Maine Historic Preservation Commission, Augusta, ME. Letter (October 2, 1978).

Sirois 1978 — Sorois, Abel, Bridge Maintenance Engineer, Maine Department of Transportation, Augusta, ME. Telephone conversation (August 29, 1978).

Soule 1975 — Soule, William H., ed. Prehistoric Peoples of Maine, Maine State Museum, Augusta, ME (1975).

Spiess 1978a — Spiess, Arthur E., Archaeologist, Maine Historic Preservation Commission, Augusta, ME. Telephone conversation (July 20, 1978).

Spiess 1978b — Spiess, Arthur E., Archaeologist, Maine Historic Preservation Commission, Augusta, ME. Telephone conversation (November 6, 1978).

Squiers 1979 — Squiers, Thomas, Marine Scientist, Maine Department of Marine Resources, Augusta, ME. Telephone conversation (March 9, 1979).

Starbird 1928 — Starbird, Charles M. The Indians of the Androscoggin Valley, Lewiston Journal Print Shop, Lewiston, ME (1928).

Stearns 1978 — Stearns, Steve, Engineering Technician, Westbrook City Engineering Office, Westbrook, ME. Telephone conversation (August 29, 1978).

Thomas 1978a — Thomas, Lynwood, Bureau of Planning, Maine Department of Transportation, Augusta, ME. Meeting (July 10, 1978).

Thomas 1978b — Thomas, Lynwood, Bureau of Planning, Maine Department of Transportation, Augusta, ME. Telephone conversation (August 9, 1978).

Thompson 1978 — Thompson, Robert, Water Quality Planner, Androscoggin Valley Regional Planning Association, Auburn, ME. Telephone conversation (August 21, 1978).

USFS 1974 — U.S. Department of Agriculture, Forest Service. The Outlook for Timber in the U.S. Forest Resource Report No. 20 (Washington: U.S. Government Printing Office, 1974).

USFWS 1978 — U.S. Department of the Interior, Fish and Wildlife Service. "List of Endangered and Threatened Wildlife and Plants," Federal Register, Part III (December 11, 1978).

USGS 1968 — U.S. Department of the Interior, Geological Survey. 1968 Water Resources Investigations in Maine, New Hampshire, USGS, Washington, DC (1968).

USGS 1974a — U.S. Department of the Interior, Geological Survey. "Hydrological Unit Map 1974, State of Maine," USGS, Washington, DC (1974).

USGS 1974b — U.S. Department of the Interior, Geological Survey. " Hydrological Unit Map 1974, States of New Hampshire and Vermont," USGS, Washington, DC (1974).

USGS 1977a — U.S. Department of the Interior, Geological Survey. Limnological Data: Report for the Maine Department of Environmental Protection - U.S. Geological Survey Cooperative Lake Studies Project, Maine Department of Environmental Protection, Augusta, ME (March 1977).

USGS 1977b — U.S. Department of the Interior, Geological Survey. Water Resources Data for Maine, Water Year 1976, Water Data Report ME-76-1, USGS, Washington, DC (1977).

USGS 1978 — U.S. Department of the Interior, Geological Survey. Water Resources Data for Maine, Water Year 1977, Water Data Report ME-77-1, USGS, Washington, DC (1978).

Wackerman, Hagenstein, & Mitchell 1966 — Wackerman, A.E.; Hagenstein, W.D.; and Mitchell, A.S. Harvesting Timber Crops (New York: McGraw-Hill, Inc., (1966).

Westbrook 1977 — City of Westbrook. Westbrook Municipal Budget, Office of the Mayor, Westbrook, ME (1977).

Westveld 1956 — Westveld, M. "Natural Forest Vegetation Zones in New England," Journal of Forestry 54 (1956).

Wharton 1978 — Warton Econometric Forecasting Associates, Inc. New England Economic Project, WEFAI, Cambridge, MA (1978).

White 1976 — White, P.S. "The Upland Forest Vegetation of the Second College Grant, New Hampshire," Ph.D. thesis, Department of Biology, Dartmouth College, Hanover, NH (1976).

Whittaker 1975 — Whittaker, R.H. Communities and Ecosystems (New York: Macmillan Publishing, 1975).

Williams 1979 — Williams, Maureen. "Travel Restrictions May Be a Boom for Maine Tourism," Bangor Daily News, Bangor, ME (March 10, 1979).

Wisler & Brater 1959 — Wisler, C.O., and Brater, E.F. Hydrology (New York: John Wiley & Sons, 1959).

Woodbury 1978 — Woodbury, Earl, Planning and Programming Engineer, New Hampshire Department of Public Works and Highways, Concord, NH. Meeting (August 23, 1978).

CHAPTER THREE: ENVIRONMENTAL IMPACTS OF THE PROPOSED PROJECT

3.1 IMPACTS OF CONSTRUCTION

3.1.1 Air Quality

The construction of the proposed wood-fired power plant will require approximately two years. During this period, the air quality of the plant site will be adversely affected by the trucks and cars needed to transport workers and materials to the site, and by the heavy construction equipment employed at the site. The impacts due to transportation in general are described in Section 3.5.3; therefore, only the impacts of construction machinery will be discussed here.

The construction process may be divided into four phases: site preparation (including pile driving), foundation laying, erection of structural steel, and mechanical construction. During the site preparation phase five earth-moving machines, a crane, and a pile-driver will be used for approximately four months (Manar 1978c). Rough estimates of hourly emissions of the five criteria pollutants from these seven pieces of equipment were developed from average Environmental Protection Agency (EPA) emission factors and are summarized in Table 3.1.1-A. These diesel-powered machines will emit significant quantities of oxides of nitrogen and carbon monoxide, and lesser amounts of hydrocarbons, sulfur oxides, and particulates. However, because the site is open, well-ventilated, and not accessible to the public, it is expected that the adverse effects on air quality in public areas will be small and short-lived. Because a detailed construction schedule has not been developed, total amounts of pollutant emissions cannot be calculated. An additional problem during this phase will be blowing soil. A very rough approximation of the magnitude of this source is 1.2 tons per acre per month of activity (EPA 1976), or roughly fifteen pounds of soil per acre per hour. However, a watering truck will be used to control dust on the roads and in areas of excavation and fill. The EPA estimates that an effective watering program can reduce fugitive dust emissions by up to 50 percent (EPA 1976).

TABLE 3.1.1-A: HOURLY EMISSIONS OF FIVE CRITERIA POLLUTANTS DURING CONSTRUCTION[1]

(pounds per hour)

	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides	Sulfur Dioxide	Total Suspended Particulates
PHASE 1[2]					
2 Scrapers	2.9	1.2	12.4	0.9	0.8
1 Wheeled Bulldizer	0.7	0.2	5.0	0.4	0.2
1 Motor Grader	0.2	0.1	1.1	0.1	0.1
1 Wheeled Tractor	2.2	0.1	1.0	0.1	0.1
1 Crane[3]	0.4	0.2	2.3	0.1	0.1
1 Pile Driver[3]	0.4	0.2	2.3	0.1	0.1
TOTAL	6.8	2.0	24.1	1.7	1.4
PHASE 2[2]					
1 Crawler Backhoe[4]	0.2	0.1	0.6	0.1	0.1
1 Wheeled Backhoe[5]	0.6	0.2	2.4	0.1	0.2
2 Cranes[3]	0.8	0.3	4.5	0.3	0.3
1 Air Compressor[6]	0.4	0.2	2.0	0.1	0.1
TOTAL	2.0	0.8	9.5	0.6	0.7
PHASE 3[2]					
4 Cranes[3]	1.6	0.6	9.1	0.6	0.6
2 Compressors[6]	0.9	0.3	4.0	0.3	0.3
TOTAL	2.5	0.9	13.1	0.9	0.9
PHASE 4[2]					
6 Cranes[3]	2.5	1.0	13.6	0.8	0.8
2 Compressors[6]	0.9	0.3	4.0	0.3	0.3
TOTAL	3.4	1.3	17.6	1.1	1.1

1. *All data from EPA emission factor (EPA 1976).*
2. *Phase 1: site preparation; Phase 2: foundation laying; Phase 3: erection of structural steel; Phase 4: mechanical construction.*
3. *Crane and pile driver emission data are from the miscellaneous category of heavy-duty, diesel-powered construction equipment.*
4. *Crawler backhoe data from tracklaying leader emission factor.*
5. *Wheeled backhoe data from wheeled loader emission factor.*
6. *Air compressor data from diesel-powered industrial equipment emission factor.*

The effects of fugitive dust away from the site are expected to be small.

The eight months of foundation work will require the use of two backhoes, two 14-ton cranes, and one large air compressor. The approximate emissions from these sources are listed in Table 3.1.1-A. Hourly atmospheric emissions will be roughly one-third of those during the site-preparation phase, although increased deliveries of concrete, steel, and equipment are expected during this phase and truck emissions will raise ambient concentrations somewhat. The net impact off the site should be small.

The third phase of construction, structural steel erection, will use four cranes of different sizes, and two large air compressors. Hourly emissions from these combustion sources will approximate those during the foundation work phase (see Table 3.1.1-A).

The use of two additional cranes during the final phase of mechanical construction will result in somewhat greater emissions than those in Phase 3 although the net hourly emissions will still be significantly less than those observed during the site preparation phase (see Table 3.1.1-A).

In general, atmospheric emissions from the site will occur primarily from the engine exhaust of diesel construction equipment and from blowing soil. The magnitude of these emissions is greatest during the site preparation phase, with lesser amounts of emissions expected during the final three phases of construction. Given the open, well-ventilated nature of the site, offsite areas are not expected to be seriously affected. Fugitive dust will be troublesome primarily during the site preparation phase; an extensive watering program will minimize this problem.

Air quality at the site itself during construction is subject to regulations of the U.S. Department of Labor, Occupational Safety and Health Administration. The standards for airborne contaminants as related to construction are described in the Federal Register of February 9, 1979 (FR 1979). It will be the responsibility of the contractor to ensure that these standards are met.

3.1.2 Hydrology and Water Quality

Construction activity at the site can be considered in two phases for the assessment of hydrologic impacts. The first phase of seven months includes site preparation and grading; the second phase of twenty-one months is primarily devoted to boiler construction. Construction activity has the potential to affect both surface water and ground water.

Surface Water

During the site preparation and grading phase of construction, the exposure of surfaces that were previously vegetated may increase surface water flow during and after storms, as well as adding to the amount of sediment transported by the surface flow. Surface runoff increase will be minimal, however, because much of the site has already been devegetated and is at present covered by roads, parking lots, storage areas, and buildings. During construction, surface preparation and grading will take place in stages, reducing the area exposed and subject to erosion at any one time. Barriers, water bars, mulch, and other devices will be employed to restrict sediment movement on the site.

The Presumpscot River should not experience increases in suspended sediments as a result of construction. The newly constructed ash ponds will be used as temporary holding ponds to contain sediment in the drainage water from the site, to prevent sediment transfer to the river. In addition, 8.4 acres of the total of 15 acres affected by the construction would drain to either the S.D. Warren sewage treatment facility or the Westbrook City sewer system, both of which would trap suspended sediment that may have passed other control measures (Finn 1979b). During normal construction operations it is expected that all sediment will be contained on site or in the holding ponds or sewer systems.

In the event of severe flooding or storms during critical stages of construction, peak surface runoff from the site may cause sediment transport rates to exceed the capacity of the on-site control system and cause increases of short duration in

the suspended sediment load of the Presumpscot River. Such events would coincide with high suspended sediment concentrations from other land areas draining into the Presumpscot. The exact probability or likely magnitude of this event cannot be assessed from data available at this time.

At the end of construction and before operation (and every five years during operation), the boiler will be cleaned with hydrochloric acid solution. The cleaning solution will be discharged into the ash ponds where it will be neutralized with ash before becoming part of the wastewater stream. This waste is included as part of the total effluents of the plant operation considered in Section 3.2.2.

No oil, paint, cleaners, solvents, or other toxic substances will be discharged into the surface or ground water or sewers during construction or operation of the plant. Any waste substances of this nature will be removed from the site by the contractors for proper disposal. No herbicides or pesticides will be used during construction (Manar 1979b).

Sanitary wastes will be disposed of into the Westbrook City sewer system or removed from the site for proper disposal by a portable toilet contractor. No sanitary waste will be discharged into surface or ground waters (Manar 1979b).

Ground Water

Construction of the boiler, the chip conveyor tunnel, and the ash ponds will require lowering the ground water table in the immediate vicinity of these areas. The total pumping rate from well points at any time will range from fifty to five thousand gallons per minute (Finn 1978). When the sedimentation level of the water being pumped is high, water will be discharged into holding ponds and allowed to clear before being discharged into the Presumpscot. Otherwise, the pumped ground water will be discharged directly through a temporary pipe into the river. The total duration of ground water pumping has not yet been determined. However, only water from the surface aquifer, which is already draining into the river, will be affected.

3.1.3 Terrestrial Ecosystems

Construction of buildings, parking lots, and wood storage areas for the proposed wood-fired power plant will result in the permanent destruction of several acres of land characterized by common annual and perennial herbaceous "weeds"--that is, of an ecosystem composed of early successional species that colonize disturbed areas. As this vegetation provides habitat for small birds and mammals, these species will also be displaced from the site. A temporary staging area, established as a parking lot for heavy equipment and a storage site for materials, will temporarily disrupt another portion of the same ecosystem. It is expected that vegetation similar to that now present will recolonize the staging area within several years after construction is completed.

Additional damage may occur to vegetation on adjacent areas of the S.D. Warren property as a result of blowing dust during construction. Dust will be controlled through use of watering trucks, however, and it is expected that the effect on vegetation will be lowered productivity during periods when the foliage is covered with dust. All of the area that will be permanently or temporarily destroyed or impacted by blowing dust has been previously used for industrial purposes and has experienced prior devegetation and other disturbance.

All species found on the site are common to disturbed areas and woodlands of Maine; no rare or endangered plants, animals, or birds are known to be present.

3.1.4 Aquatic Ecosystems

No detectable change in water quality in the Presumpscot River is expected to result from the construction of this plant (see Section 3.1.2), nor will there be any changes in the condition of the river banks. Therefore, no impact on aquatic or riparian ecosystems is expected.

3.1.5 Land Use

Construction of the proposed wood-fired, steam-electric station will have a small indirect impact on land use in the adjacent community. The facility is contemplated to be constructed on land that is presently used by industry. Although the project will not directly demand the opening of new industrial acreage, approximately 8.5 secondary industrial-use acres will be used for primary industry. The Mason's Building and Salvage Building, which together occupy approximately one acre of land, will be demolished in order to allow space for the wood-fired facility, which will occupy approximately 9.5 acres.

Construction of the wood-fired facility will not significantly reduce the need for construction of new electrical generating stations. The Central Maine Power Company is currently planning construction of a 600-megawatt coal-fired generating plant, Sears Island #1, scheduled for start-up in 1986 (Carpenter et al. 1977). The 18 megawatts of electricity that the wood-fired facility will make available to Central Maine Power Company for public use (Finn 1979a) will not replace the need for, nor delay construction of, Sears Island. However, if a series of cogenerating plants were constructed in New England, the need for additional development of land to support large power plants could be reduced.

During the two-year construction period, a maximum of eight construction supervisors and one hundred and fifteen construction laborers will migrate into Greater Portland. Fifty percent of these supervisors and laborers are expected to bring families (see Section 3.1.6). Assuming each family will choose to live in a detached housing unit and each single laborer will choose to live in an attached housing unit, the maximum housing demand generated by plant construction will be sixty-two detached units and sixty-one attached units. Actual demand will probably be less than maximum, however, due to the fact that single workers may choose to commute, live in campers or trailers, or share

attached units. In addition, some families may occupy attached units.

According to a Portland Area Comprehensive Transportation Study (PACTS) projection, approximately 5,200 attached units and 8,400 detached units will be constructed in Greater Portland between 1975 and 1990 (PACTS 1978). Currently, the average amount of land occupied by each type of dwelling varies widely between municipalities. The average acreage per attached unit varies from .08 acres, in Portland, to .5 acres, in Scarborough. The average acreage per detached unit varies from .1 acres, in Portland, to 1.0 acre, in Cumberland and Gorham (PACTS 1977). Thus, given the previously stated maximum demand of sixty-two detached units and sixty-one attached units and assuming each family and laborer will directly or indirectly stimulate the construction of a new unit, construction of the proposed wood-fired facility could be responsible for the conversion of up to ninety-three vacant acres to residential usage within Greater Portland. Actual residential development resulting from the influx of construction workers is expected to be much less widespread.

Most new attached units will be located in the central municipalities of Portland and South Portland (PACTS 1978), however, where each such unit currently occupies an average of 0.03 acres (PACTS 1977). Most new detached units will be located in the peripheral communities of Windham, Gorham, and Scarborough (PACTS 1978), where each such unit currently occupies an average of 0.8 acres (PACTS 1977). Thus, assuming the sixty-one single workers will be more apt to live in new attached units in Portland or South Portland, and the projected sixty-two families will be more apt to seek detached units in Gorham, Windham, or Scarborough, fifty-two vacant acres within Greater Portland will be converted to residential usage as a result of this project. This figure represents less than .3 percent of the current total residential acreage of 18,363 acres (PACTS 1977).

Construction of the proposed wood-fired facility will indirectly result in small commercial and industrial land use

acreage increases in Greater Portland. These increases have been estimated using PACTS current land use acreage data, PACTS current employment levels data, and data on indirect employment generated by plant construction (see Section 3.1.6), for trade, services, and industry. Calculations indicate that industrial acreage is likely to increase by seven acres, or 1.1 percent of the current total industrial acreage. Commercial (trade plus services) acreage is likely to increase by twenty-six acres, or .8 percent of current total commercial acreage. See Table 3.1.5-A for a summary of these data and calculations.

Environmental degradation during plant construction will not be extensive (see Sections 3.1.1 and 3.1.2) and will not impact land use patterns surrounding the proposed plant site. S.D. Warren employees auto traffic and truck traffic will increase during plant construction (see Section 3.5.3). Large numbers of additional vehicles could impact land use patterns in the surrounding community if they entered or left the plant site during peak traffic hours, 7 a.m. to 9 a.m. or 3 p.m. to 5:30 p.m. (Day 1979), and travelled sensitive traffic routes. Trucks carrying construction materials to the plant site should not present a problem, however, as truck arrivals and departures will occur sporadically throughout the day and will not greatly increase total truck traffic volumes (see Section 3.5.3).

Peak-hour auto traffic in Westbrook could increase significantly during plant construction if the 240 to 350 construction laborers and estimated 262 subcontracted laborers travel to and from the plant site during these hours (see Section 3.1.6). Assuming 1.1 persons per auto, a maximum of 550 additional autos could enter and leave the site each day. However, as both the construction work day and number of laborers will vary, construction auto traffic during peak hours will rarely equal the stated maximum. If the workers travel through sensitive residential areas where traffic volumes are already near capacity during peak hours, congestion and noise could increase and safety decrease. Residential areas susceptible to large traffic increases are located along Conant Street, Saco Street, Spring Street, South

TABLE 3.1.5-A: LAND USE INCREASES GENERATED BY CONSTRUCTION OF PROPOSED FACILITY

Greater Portland Land Use Sector	Current Acreage[1] *(A)*	Current Employment[1] *(B)*	Acres/ Employee *(A/B)*	New Employment[2] *(C)*	New Acreage *(A/B) x C*
Industry	636	11,457	0.06	121	7
Trade	889	15,330	0.06	201	12
Services	2,197	26,392	0.08	169	14

1. *Source: PACTS 1977.*

2. *Source: Appendix E.*

Main Street, Cumberland Street, and Bridge Street (see Section 2.1.7). Construction will continue for only two years, however, and land use patterns are not likely to change because of traffic increases over that period.

Ambient noise will increase in the plant site community during construction , particularly in the residential areas adjacent to the construction site (see Section 3.1.7). Numerous factors will prevent high noise levels from impacting land-use patterns. Construction will last for only two years, and most construction activity will take place during the daylight hours. In addition, the community has had much experience with high noise levels produced by the S.D. Warren mill (see Section 2.1.9) and will probably not be highly sensitive to construction noise (estimated from Eldred 1971).

3.1.6 Socioeconomic Characteristics

Employment and Unemployment

During the two-year construction period, eight construction supervisors will direct an average of about 240 construction workers. At peak, 350 construction workers will be employed (Milligan 1977). Table 3.1.6-A provides an approximate breakdown of the number of each type of construction worker that will be required by the project. In addition to those employed by the construction engineering firm, approximately 262 workers will be employed during each of the two construction years by local subcontractors supplying services to the project. No breakdown on the type of labor required of the subcontractors has yet been prepared.

The employment generated by the proposed construction of the wood-fired power plant combined with local expenditures for construction materials will stimulate indirect employment within the Greater Portland area. To determine the number of indirect employment opportunities likely to be created in addition to those positions with local subcontractors, the Bureau of Economic Analysis regional impact model for Cumberland County was employed.

TABLE 3.1.6.-A: NUMBER OF CONSTRUCTION WORKERS BY TRADE

TRADE	AVERAGE	PEAK
Laborer	32	46
Carpenter	27	39
Millwright and Rigger	24	35
Iron Worker	28	40
Cement Finisher	4	6
Operator	8	12
Teamster	2	3
Boilermaker	2	3
Steamfitter	74	107
Electrician	39	57
TOTAL	240	348

Calculated from Manar 1978a and Milligan 1977.

This analysis predicted that approximately 491 persons will be indirectly employed during the two-year construction period and that retail and wholesale trade will experience the largest increases in employment (see Appendix E). Thus, total direct and indirect employment stimulated by the construction of the proposed plant will average about 1,000 workers during the two-year construction period.

The maximum reduction in regional unemployment would occur if all 240 construction workers, 262 subcontracted workers, and 491 indirectly employed persons were drawn from the local pool of unemployed workers. In 1978, 4,100 workers on average, or 4.9 percent of the Portland area's labor force, were unemployed (Donahue 1979). The creation of 993 new positions would reduce the Greater Portland area's unemployment rate to 3.7 percent if all jobs were taken by those currently without work. In fact, it is likely that some workers for the project will migrate into the area or transfer from their present employment, so that the actual reduction in unemployment will be somewhat lower.

Upon completion of construction, there will be a decline in business activity. Some workers employed both directly and indirectly by the project may again be unemployed.

Income

Salaries and wages paid to supervisors and workers employed directly by the construction contractor will total approximately $4.6 million per year during the two-year construction period (Milligan 1977). Additionally, $10.5 million will be paid to subcontracting companies providing construction services (Milligan 1977). About one-half of this amount will go to labor in the form of wages.

The construction phase will also generate expenditures for materials in the local economy. Table 3.1.6-B summarizes the net annual expenditures made during the contruction period that will accrue to the local economy. It does not include that portion of expenditures that accrues to manufacturers or wholesalers outside of the Greater Portland area. Approximately $568,000 of direct net local income will be generated annually from materials

TABLE 3.1.6-B: ANNUAL DIRECT LOCAL INCOME ACCRUING FROM PLANT CONSTRUCTION

Construction salaries		$ 4,600,000[1]
Subcontractor fees		10,500,000[1]
Materials expenditures		
Lumber	$ 35,000[3]	
Ready-mix concrete	315,000[3]	
Wholesale trade	9,000[1]	
Shipping, motor freight	9,000[1]	
Piping	200,000[2]	
Subtotal		568,000
TOTAL		$15,668,000

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1. *Calculated from Milligan 1977.*
2. *Calculated from Manar 1978b.*
3. *Calculated from Manar 1979d.*

expenditures (Manar 1978b; Manar 1978d; Milligan 1977).

Total direct regional income resulting annually from the construction of the proposed wood-fired power plant will average about $15.7 million. The Bureau of Economic Analysis regional impact model predicts that this direct income will generate approximately $18.7 million of indirect income. The indirect socioeconomic effects are discussed in more detail in Appendix E.

State Revenues

The state of Maine will receive additional revenues as a result of the construction of the proposed wood-fired power plant. Direct and indirect salaries and wages will be subject to the state's personal income tax. Personal income tax paid annually on the salaries and wages of the eight supervisors, 240 construction workers, and 262 subcontracted employees will total approximately $317,000. The 491 persons indirectly employed by the project together will pay about $125,000 of combined personal income tax (see Table 3.1.6-C).

Sales tax must be paid to the state of Maine on taxable construction materials purchased. Projected annual sales tax to be paid during the two year construction period is shown in Table 3.1.6-D. Sales tax revenues from direct construction purchases should total about $92,500 annually. Also, some expenditures stimulated indirectly through the multiplier effect will be taxable and will generate revenues for the state. Sales tax on these expenditures is expected to total about $516,000 annually (see Appendix E).

When combined, personal income tax on direct and indirect construction salaries and sales tax on direct and indirect construction purchases will total approximately $1.1 million.

Population Growth and Growth Trends

It is expected that the majority of construction positions, subcontracted jobs, and indirect employment opportunities will be filled by persons currently living within the Greater Portland area. The magnitude of the contemplated construction project is small when compared with the level of economic activity in the Greater Portland area and a boom town atmosphere will not be

TABLE 3.1.6-C: MAXIMUM MAINE STATE INCOME TAX REVENUES FROM WORKERS DURING CONSTRUCTION PERIOD

	SUPERVISORS	CONSTRUCTION WORKERS	SUBCONTRACTED WORKERS *(Indirect Construction)*	OTHER INDIRECT EMPLOYMENT
Average Number of Workers	8	240	262	491
Average Salary	$29,000	$18,837	$18,837	$13,000
less standard deductions[1]	2,800	2,800	2,800	2,100
less exemptions[1]	3,000	3,000	3,000	3,000
Total Taxable Income per Person per Year	23,200	12,587	12,587	7,900
Maine State Income Tax[1]	1,538	607	607	254
Total State Income Tax Revenue	$12,304	$145,680	$159,034	$124,714

Total State Income Tax Revenues from Salaries **$441,732**

1. Source: CCC 1978.

TABLE 3.1.6-D: ANNUAL MAINE SALES TAX ON DIRECT CONSTRUCTION PURCHASES

ITEM	RETAIL COST *(dollars)*	SALES TAX[3] *(dollars)*
Piping	1,500,000[1]	75,000
Lumber	35,000[2]	1,750
Ready mix concrete	315,000[2]	15,750
Total Sales on Direct Purchases		92,500

1. *Source: Manar 1978b.*
2. *Source: Manar 1979d.*
3. *Calculated from Cleaves 1978.*

created. In addition, two major construction projects will be completed in the period of time before construction of the proposed wood-fired power plant and approximately 772 construction workers, therefore, will be seeking new employment opportunities (Clifford 1978; McPherson 1978). Nonetheless, an analysis of available construction workers does indicate that some workers with specific skills will have to come to the project from outside the region. Table 3.1.6-E itemizes the number of construction workers by trade that may migrate into the Greater Portland area as a result of this project. The total number of workers expected to immigrate ranges between 54 and 115. In addition, eight construction supervisors almost certainly will come from outside the region. Assuming that half of these project employees brought average size families with them, a total of 130 to 260 people would migrate to the region for the construction phase. This influx of people would increase the population of the Greater Portland area by approximately 0.1 percent.

Social Impact within the Community

The proposed power plant will be constructed on S.D. Warren Company land. No houses will have to be sold or demolished prior to the construction of the plant nor will there be speculative gains from the sale of land.

Local construction workers may resent other workers immigrating from outside the region. However, while Westbrook's sewage treatment plant was being constructed, there were 157 construction workers in the city (Clifford 1978) and no adverse impacts occurred within the community (Parks 1978).

Education

Some of the construction workers migrating to the Greater Portland area can be expected to bring their children with them. Of the maximum 260 people expected to migrate to the region, no more than seventy-five would be likely to be school age children. In the 1975-1976 school year, there were about 39,000 children enrolled in schools throughout the Greater Portland Standard Metropolitan Statistical Area (GPCOG 1977). Thus, the additional children would result in a school enrollment increase of about 0.2

TABLE 3.1.6-E: NUMBER OF WORKERS EXPECTED TO MIGRATE TO THE GREATER PORTLAND AREA FOR CONSTRUCTION OF THE PROPOSED POWER PLANT

TRADE	NUMBER
Millwright	9-17
Iron Worker	0-14
Operator	0-7
Steamfitter	45-59
Electrician	0-18
Total	54-115

Source: Appendix E.

percent. Even if all 240 projected construction workers immigrated from outside the region and each brought a family of three people, school enrollments would increase by no more than 290 children or about 0.7 percent.

Health Services, Public Assistance, and Social Services

There will be a decline in aid to families with dependent children and food stamp expenditures if persons currently unemployed are hired by the project. After construction, these expenditures may return to their original or slightly higher levels.

Construction work in Maine has an incidence rate of injury and illnesses related to work of 14.7 per 100 fulltime workers per year (MDMA 1976). Therefore, of the 240 construction workers and 280 subcontracted employees, approximately seventy-five injuries can be expected during each of the two years of construction. Of these work-related injuries, approximately 44 percent or thirty-three in total could be expected to result in work-days lost. This accident rate will not strain hospital capacity in the Greater Portland area.

3.1.7 Archaeologic, Historic, Cultural, and Aesthetic Resources

Archaeologic

The site of the proposed wood-fired steam-electric station is of no archaeological value. Construction will have no impact on archaeologic resources (Shettleworth 1978a).

Historic

Construction of the proposed wood-fired facility will have negligible impact on historic resources, either on structures within the Cumberland Mills Historic District or on other historic areas of Greater Portland. Two mill buildings will be demolished in order to allow space for plant construction: the Mason's Building, erected in 1917, and the Salvage Building, erected in 1921 (Bittner 1978). The Maine Historic Preservation Officer has determined that these buildings are not included in the Cumberland Mills Historic District (see Section 2.1.9) and, therefore, that

their demolition is not in violation of the National Historic Preservation Act of 1966 (Shettleworth 1978b). The number of potential visitors to historic sites may increase slightly: an estimated 130 to 260 persons will migrate into Greater Portland during construction (see Section 3.1.6). Environmental impacts will be localized and will not affect historic resources (see Sections 3.1.1-3.1.4).

Cultural

Construction of the proposed wood-fired facility will not impact cultural resources of the surrounding community. The population demanding cultural services will increase by 130 to 260 persons, or less than .1 percent of Greater Portland's current total population (see Section 3.1.6). Environmental impacts will be localized and will have no secondary effects on cultural resources (see Sections 3.1.1-3.1.4).

Aesthetic

Construction of the proposed wood-fired facility will have a strong aesthetic impact on the plant site and a smaller aesthetic impact on the surrounding community. During the two-year construction period, staging and partially erected structures, construction materials, and heavy machinery will occupy an area of approximately fifteen acres. This entire area will be noticeable from Park Road and the noise will be heard in town. Within the limits of the construction area, fugitive dust will result in increased opacity near ground level. Erosion and sedimentation will be controlled (see Section 3.1.2), thereby minimizing aesthetic impacts related to water quality.

The completed wood-fired facility will include the boiler house, stack, cooling tower, ash ponds, woodyard facility, and wood chip pile. The structure having the greatest and most far-reaching visual impact will be the stack, which will rise three hundred feet from ground level to an elevation of about 345 feet. The existing S.D. Warren stack rises 353 feet above the ground level to an elevation of about 395 feet. Thus the top of the new stack will be fifty feet below the top of the existing stack and the new stack will be visible from almost every point from which

the existing stack is visible. The two stacks will appear to be nearly equal in height. The next tallest S.D. Warren structure, the recovery boiler stack, is only half as tall (162 feet) and is visible only in the immediate vicinity of the plant (Hills 1979b). The recovery boiler stack is located just north of the existing stack.

The wood chip pile and woodyard facility will become prominent foreground structures of the mill. These structures will extend approximately 1,400 feet along S.D. Warren's western boundary, within one to two hundred feet of Park Road. The 1,000-foot long, 40-foot tall wood chip pile will be uncovered and will rise to an elevation thirty feet higher than that of Park Road. The chip pile will block the western view of the lower structures of the mill complex. The woodyard facility, situated south of the chip pile, will be an irregular metal structure of varying elevation, characterized by slanting roofs, conveyors, and a central tower-like structure. The four tallest segments of the facility will rise to between thirty-five and sixty-five feet above the level of Park Road. Depending on the location of the observer, this structure will also block the view of much of the S.D. Warren plant.

The boiler house will be rectangular in shape and will occupy approximately .75 acres immediately to the west of the S.D. Warren mill complex. With a height of 148 feet, the boiler house will be the tallest building of the S.D. Warren industrial complex, rising to within fifteen feet of the top of the recovery boiler stack. When viewed from the west, the boiler house will occupy a central and prominent position in the mill landscape, except where blocked by the chip pile or woodyard facility. The top portion of the building will be visible from the east, behind and above the older S.D. Warren mill structures.

The ash ponds will be hidden from view between the mill complex and the elevated railroad tracks. The upper portion of the relatively small cooling tower (the floor area is 2,500 square feet and the elevation one hundred feet) will be visible above the railroad tracks, but in other places will be blocked from view by

the chip pile or woodyard facility.

Noise Impacts

Construction of the proposed wood-fired facility will raise ambient noise levels in the surrounding community. Levels will increase most in those areas located immediately adjacent to the construction site. To facilitate a noise impact analysis, construction activity can be considered in terms of four distinct phases, each differentiated by the types of construction equipment in use. Phase I, characterized by heavy earth-moving equipment, will be the noisiest phase, generating an equivalent 24-hour sound level of seventy-two decibels at five hundred feet. The 24-hour sound level will steadily decline with each subsequent phase to a low of sixty-six decibels at five hundred feet during Phase IV. The 24-hour sound level for the entire two-year construction period will be seventy decibels at five hundred feet (see Appendix H) (Griffin 1979a).

Table 3.1.7-A summarizes the ambient noise level change during each phase of construction at each of six S.D. Warren test stations. Figure 3.1.7-A depicts the location of each station in relation to the construction site. As calculations are based on the sound level of each piece of equipment at a fixed distance from each test station to the center of the construction site, sound level estimates may be slightly inaccurate. Construction equipment will be located at varying distances from each test station, and many pieces will move around the site throughout the work day.

Noise levels will increase most at Stations 3 and 4, where the equivalent 24-hour sound level will rise by thirteen and ten decibels, respectively over the two-year period. In this area, residential land use predominates. Station 4 is also the site of the Westbrook Community Hospital. Stations 1 and 2, located south of and adjacent to the S.D. Warren mill, will experience a 24-hour sound level increase of three decibels over the construction period. Total ambient noise levels will remain highest here, due to the overriding influence of mill sound levels. Increases will be lowest at Stations 5 and 6, located east of the

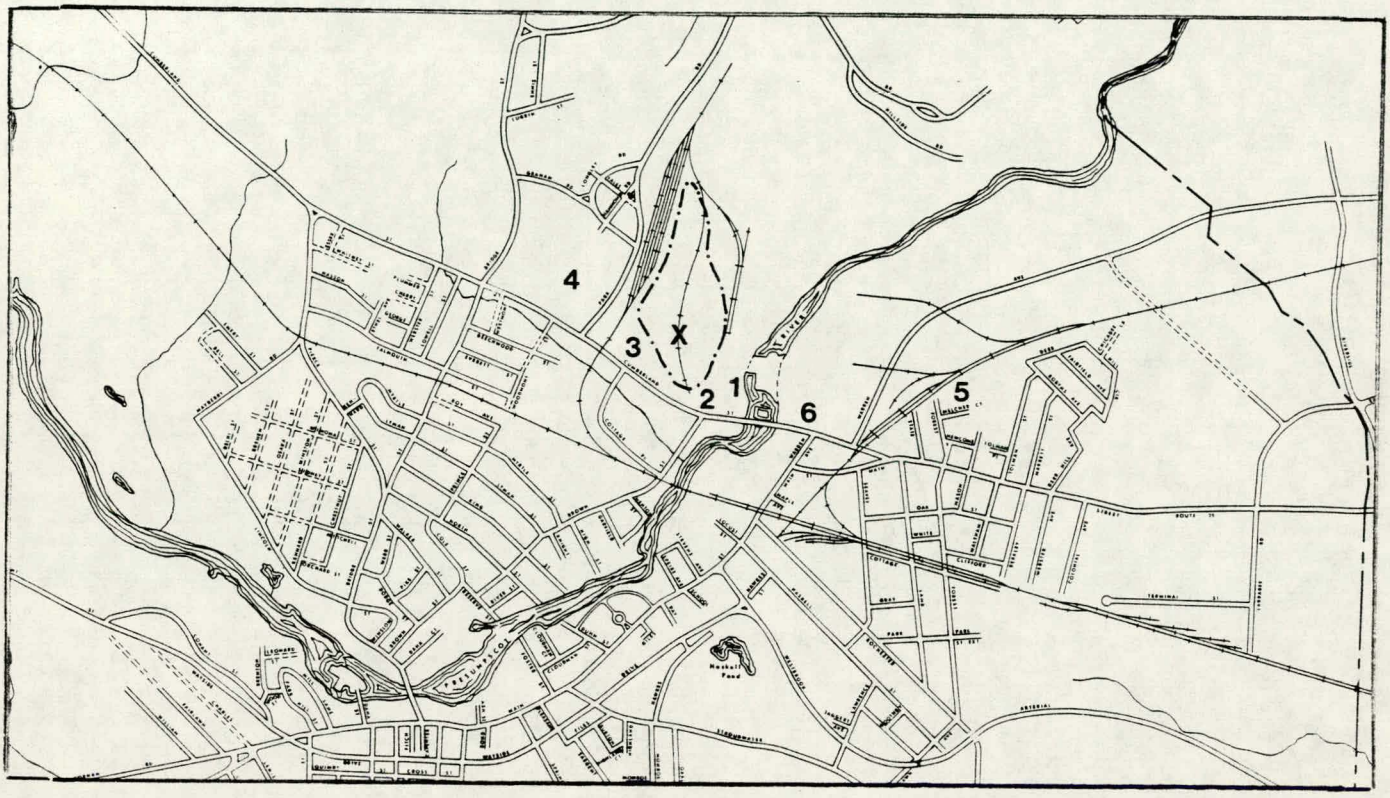
TABLE 3.1.7-A: AMBIENT NOISE LEVELS DURING FOUR PHASES OF PLANT CONSTRUCTION

(dBA)[1]

Test Station	Present S.D. Warren Sound Level[2]		Phase I[5] (4 months)						Phase II[5] (8 months)						Phase III[5] (6 months)						Phase IV[5] (6 months)						Total Construction Period (2 years)					
			Construction Noise		Total S.D. Warren Sound Level		Increase		Construction Noise		Total S.D. Warren Sound Level		Increase		Construction Noise		Total S.D. Warren Sound Level		Increase		Construction Noise[2]		Total S.D. Warren Sound Level		Increase		Construction Noise		Total S.D. Warren Sound Level		Increase	
	A[3]	*A-P*[4]	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*	A	*A-P*
1. Cumberland St. & Gatehouse	65	*71*	67	*67*	69	*73*	4	*2*	66	*66*	69	*72*	3	*1*	62	*62*	67	*71*	2	*0*	61	*61*	67	*71*	2	*0*	65	*65*	68	*72*	3	*1*
2. Cumberland St. & Brown St.	65	*71*	66	*66*	69	*73*	4	*2*	65	*65*	68	*72*	3	*1*	61	*61*	67	*71*	2	*0*	60	*60*	66	*71*	1	*0*	64	*64*	68	*73*	3	*2*
3. Cumberland St. & Cottage St.	53	*58*	68	*68*	68	*68*	15	*10*	67	*67*	67	*67*	14	*9*	63	*63*	63	*64*	10	*6*	62	*62*	62	*64*	9	*6*	66	*66*	66	*67*	13	*9*
4. Westbrook Community Hosp.	54	*60*	66	*66*	66	*67*	12	*7*	65	*65*	65	*66*	11	*6*	61	*61*	61	*64*	7	*4*	60	*60*	61	*63*	7	*3*	64	*64*	64	*66*	10	*6*
5. Lower Forest St. - End	47	*52*	57	*57*	57	*58*	10	*6*	56	*56*	56	*58*	9	*6*	52	*52*	53	*55*	6	*3*	51	*51*	52	*55*	5	*3*	55	*55*	56	*58*	9	*6*
6. Cumberland St. & Warren Ave.	62	*67*	61	*61*	65	*68*	3	*1*	60	*60*	64	*68*	2	*1*	56	*56*	63	*67*	1	*0*	55	*55*	63	*67*	1	*0*	59	*59*	64	*68*	2	*1*

1. *dBA = decibels on A-weighted scale.*
2. *Source: Johnson 1974.*
3. *A = Annual average of $L_{eq(24)}$, or equivalent sound levels over 24 hours.*
4. *A-P = Annual average of L_{dn}, or equivalent sound levels over 24 hours with 10-decibel penalty applied 10 p.m.-7 a.m.*
5. *Source: Griffin 1979a.*

FIGURE 3.1.7-A: LOCATION OF THE SIX S.D. WARREN NOISE TEST STATIONS



KEY

— · — · — construction site boundry

X center of construction activity

mill and furthest from the construction site. Although Table 3.1.7-A indicates a relatively large ambient noise increase at Station 5, this impact is unlikely to actually occur. Calculations assume a free acoustical field, even though the entire S.D. Warren industrial complex is located between Station 5 and the construction site. Thus, construction noise will be minimal east of the mill.

The present average day-night sound levels of Stations 1,2,3, 4, and 6 are seventy-one, seventy-one, fifty-eight, sixty, and sixty-seven decibels, respectively. These levels exceed the outdoor day-night sound levels which the U.S. Environmental Protection Agency has identified as requisite to protect the public against physiological damage, hearing loss, and activity interference. The requisite level for residential and hospital environments, represented by Stations 3 and 4, is fifty-five decibels. The requisite level for commercial and industrial environments, represented by Stations 1, 2, and 6, is sixty-five decibels (EPA 1974). The day-night levels of Stations 3 and 4 will rise by nine and six decibels to annual averages of sixty-seven and sixty-six decibels, respectively. The day-night levels of Stations 1, 2, and 6 will rise by one, two, and one decibel to annual averages of seventy-two, seventy-three, and sixty-eight decibels.

Sound levels will increase markedly in the immediate plant vicinity, and the radius within which ambient noise exceeds recommended levels will expand. However, as construction activity will decline markedly or cease completely at night, nightime sound will actually remain approximately at present levels and sleep interference will not increase. Construction sound levels in the surrounding community will very rarely, if ever, exceed ninety decibels, the threshold of physiological damage. However, during construction activity, normal outdoor speech communicaiton will be hindered (Bragdon 1970). In any case, these ambient noise increases will not be permanent, but will cease after two years. The most severe impacts will occur in the first months of construction and ambient noise will decrease as construction progresses.

The Occupational Safety and Health Administration (OSHA) regulations applying to noise in the construction industry require that protection against the effects of noise exposure be provided when sound levels exceed those outlined in Table 3.1.7-B. OSHA requires that feasible administrative or engineering controls be implemented to the extent possible. Personal protective equipment ("earphone" type headgear is required if administrative and engineering controls are not fully effective. Exposure to impulsive (impact) noise cannot exceed the 140 dB peak sound pressure level. OSHA requires that a hearing conservation program, including audiometric testing be administered periodically when noise levels exceed those in Table 3.1.7-B. Hearing protection equipment would be required at the Westbrook construction site.

TABLE 3.1.7-B: PERMISSIBLE NOISE EXPOSURE

Duration per day (hours)	Sound Level dBA slow response
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
<0.25	115

Source: OSHA 1979

3.2 IMPACTS OF OPERATION

3.2.1 Air Quality Impacts of Plant Operation

Description of Existing S.D. Warren System

The proposed wood-fired power plant will replace boilers that currently operate at the S.D. Warren Company mill. At present, S.D. Warren is licensed to operate four oil-fired steam boilers and one bark- and oil-fired boiler at this site. These boilers' maximum fuel consumption totals 7.2 tons per hour of dry bark and 6,540 gallons per hour of Number 6 fuel oil at 2.1 percent sulfur. Fuel consumption of these boilers varies seasonally and is about twice as high in winter as in the summer.

S.D. Warren proposes to retire the bark boiler and two oil boilers when the biomass boiler comes on line. Boiler #20 will continue to operate, when necessary, as a swing boiler, firing up to 1,675 gallons per hour of Number 6 fuel oil at 2.1 percent sulfur. S.D. Warren proposes to safeguard its supply of process steam by maintaining the ability to bring the other boilers back on line in the event of scheduled or unscheduled shutdowns of the proposed new power plant. In these cases, the existing boilers would operate simultaneously with the proposed wood-fired system for periods not to exceed twenty hours. These events should occur no more than several times per year. The fuel firing capacity of the existing S.D. Warren boilers and the proposed wood-fired boiler are shown in Table 3.2.1-A.

Description of Proposed System

In normal operation, the proposed wood-fired power plant will burn one thousand oven-dry tons of wood and wood waste daily in a moving-grate boiler. In addition, one furnace burner will continuously fire up to two thousand gallons of Number 6 fuel oil (containing 2.1 percent sulfur) per day to maintain a standby fuel source. Fuel consumption will total 16.8×10^9 Btu from wood and 0.3×10^9 Btu from oil daily. Hourly fuel consumption rates will average 700×10^6 Btu and 12.3×10^6 Btu from wood and oil respectively. For air quality impact analysis, it has been

TABLE 3.2.1-A: FUEL-FIRING CAPABILITY OF EXISTING PLANT AND PROPOSED FACILITIES[1]

	Existing S.D. Warren Boiler System	Proposed Wood-fired System
Fuels	Oil and Bark	Wood and Oil
Fuel Firing Rate		
Normal Operation	Oil: 6,540 gallons/hour Bark: 174 dry tons/day	Wood: 1,000 dry tons/day Oil: 60 gallons/hour[2]
Emergency Oil-only Operation		3,720 gallons/hour
Total Btu Input Rate	968.5 x 10^6 Btu/hour	550-750 x 10^6 Btu/hour

1. *All oil burned is Number 6 and contains 2.1% sulfur, except for oil burned in emergency oil-only operation, which is 0.7% sulfur.*
2. *Based on 1.5% of maximum Btu input capacity.*

Source: S.D. Warren 1978.

assumed that the facility will operate continuously at a constant rate for 350 days per year.

The proposed wood-fired boiler will be equipped with emergency oil-burning capacity equivalent to its wood-firing capacity. During start-up, or when wood cannot be fed to the boiler due to wood-handling system malfunction, oil will be fired at a rate not to exceed sixty-two gallons per minute (89,200 gallons per day) to maintain normal steam production. In these situations, low-sulfur oil containing less than 0.7 percent sulfur will be fired through a separate oil-metering system. Similarly, when wood fuel having a moisture content greater than 60 percent enters the boiler, the oil-firing rate will increase to a maximum of five gallons per minute but will not exceed seven thousand gallons per day. Oil fired on this basis will contain 2.1 percent sulfur.

Current Emissions

Testing of the stack gases from three oil-fired boilers and emissions estimates for the bark-fired boiler now in use at S.D. Warren suggest that the maximum particulate emission rate from the company's boiler system totals 20.7 grams per second (Hills 1978). Actual emissions of sulfur dioxide, nitrogen oxides, carbon monoxide, and hydrocarbons have not been measured, but estimates have been compiled using emission factors prepared by the U.S. Environmental Protection Agency. A wide range is given for emission factors for hydrocarbons and carbon monoxide from bark-fired boilers. The higher values apply to older boilers in which the combustion is less well controlled. It was judged that the S.D. Warren boiler probably emits hydrocarbons and carbon monoxide at a rate between two and ten pounds per ton of bark burned. This range has been used in the trade-off analysis which follows. A more exact estimate would require stack sampling of the S.D. Warren plant. Estimates of current-emissions are shown in Table 3.2.1-B. The table also shows emissions for boiler #20 operating alone, since this boiler will continue to operate as a swing boiler after the wood fuel boiler comes on line.

TABLE 3.2.1-B: EMISSION RATES FROM EXISTING S.D. WARREN BOILERS

	Total Suspended Particulates	Sulfur Dioxide	Nitrogen Oxide	Hydro-carbons	Carbon Monoxide
ANNUAL EMISSIONS[1,2,3] *(tons/year)*					
Full capacity operation	700[4]	7,540	1,270	80-330	180-420
Boiler #20 only	140	2,330	370	6.7	34

1. *All oil is 2.1% sulfur.*
2. *Calculated from EPA 1976 unless otherwise noted.*
3. *Assumes facility operates 350 days/year*
4. *Based on emission rates observed in 1977 (Hills 1978).*

Estimated Emissions from Proposed Wood-fired Boiler

Particulate emissions. Two mechanical separators and an electrostatic precipitator will be used to control particulate emissions from the proposed wood-fired boiler. This system achieves an efficiency of approximately 99 percent in removing particulate matter from the smoke stream. During normal combustion of wood with standby oil firing, the particulate emission rate is anticipated to be 235 tons per year. This amount is well below the U.S. Environmental Protection Agency's New Source Performance Standard for mixed fuel boilers. However, for the purposes of the impact assessment below, the more conservative New Source Performance Standard value of 313 tons per year has been employed (see Appendix B for analytical details).

Sulfur oxide emissions. Total emissions of various oxides of sulfur are expressed here in terms of sulfur dioxide. Based on the U.S. Environmental Protection Agency emission factor of 1.5 pounds of sulfur dioxide per dry ton of wood burned (EPA 1976), sulfur dioxide emissions from the combustion of the wood should be about 0.75 tons per day. Sulfur dioxide emissions from the standby oil firing are expected to be 0.3 tons per day; therefore, total sulfur dioxide emissions during normal operations should be less than 1.05 tons per day (11.0 grams per second). During periods of reduced fuelwood drying, when fuel oil is burned at a rate of up to 5.5 percent of the total Btu input, sulfur dioxide emissions will increase to 1.86 tons per day or 19.5 grams per second. The New Source Performance Standard for mixed fuel boilers is 55.5 grams per second (CFR 1977).

Nitrogen oxide emissions. Total emissions of various oxides of nitrogen are expressed here in terms of nitrogen dioxide. The Environmental Protection Agency's emission factor for nitrogen dioxide from wood-fired boilers is 10 pounds per green ton of wood burned (1.2 pounds per 10^6 Btu input) (EPA 1976). This rate is considerably greater than the emission factor for oil, which is 0.3 pounds per 10^6 Btu (EPA 1976). Analysis of the assumptions on which the wood emission factor is based and of new measurements indicates that the EPA factor is probably high. Combustion

analyses performed by the Department of Energy's engineering contractor indicated that emissions of nitrogen dioxides from the proposed boiler will be less than 5.37 tons per day (Manar 1979c). This is equivalent to 57.9 grams per second. This emission rate was used for all analyses.

Carbon monoxide emissions. The Environmental Protection Agency emission factor for carbon monoxide from wood combustion is 2 to 60 pounds per ton of dry wood. The lower values apply to combustion in well-designed boilers. Combustion analyses obtained by the Rust Engineering Company indicated that emissions of carbon monoxide from the proposed boiler equivalent to 1.79 tons per day or 18.1 grams per second (Manar 1979d). This emission rate was used for all analyses.

Hydrocarbon emissions. The Environmental Protection Agency emission factor for hydrocarbons from wood combustion is 2 to 70 pounds per ton of dry wood. Combustion analyses performed for Rust Engineering indicated that hydrocarbon emissions from the proposed boiler will be equivalent to 0.21 tons per day or 2.1 grams per second, expressed as methane (Manar 1979d). Total hydrocarbon emissions will therefore be approximately 70 tons annually. This is less than the one-hundred ton per year incremental limit imposed by the state of Maine on sources in Westbrook, which is a nonattainment region for ozone (Chandler 1978). Table 3.1.2-C summarizes the source strengths of the major pollutants to be emitted from the proposed plant under varying operating conditions. (All calculations are presented in detail in Appendix B.)

Emissions of hazardous pollutants. The atmospheric particulate emissions from the proposed boiler contain additional materials known to be hazardous in large quantities, but which are not presently regulated by federal law. Chief among these are various trace elements, including arsenic, selenium, cadmium, chromium, and lead, which have volatile oxides or chlorides that are released from the fuel during combustion. Published wood analyses give concentrations only for major components. A sample of New England white pine and of red maple were therefore analyzed for trace metals of intermediate atomic weight by means of x-ray

TABLE 3.2.1-C: EMISSION RATES FROM PROPOSED WOOD-FIRED PLANT UNDER VARIOUS OPERATING CONDITIONS

	Total Suspended Particulates	Sulfur Dioxide	Nitrogen Oxide	Hydro-carbons	Carbon Monoxide
ANNUAL EMISSIONS[1,2] *(tons/year)*					
Normal Operation[3]	320[4]	370[5]	1,930[6]	70[6]	600
Normal Operation plus #20 Boiler	460	2,700	2,300	77	630
Emergency Oil-only Operation[7]	1.7[8]	1,700	690	16	77
Boiler #20 Only	140[9]	2,330	370	6.7	34

1. *Based on EPA 1976 unless otherwise stated.*
2. *Assumes plant operates 350 days per year.*
3. *Plant operating on 98.5% wood and 1.5% oil with full wood drying.*
4. *Based on New Source Performance Standard for mixed fuel oil boilers of 0.1 pounds/10^6 Btu (CFR 1977).*
5. *Includes contribution from sulfur in wood.*
6. *Calculated from Manar 1979d.*
7. *Fuel oil 0.7% sulfur.*
8. *Based on EPA 1976 and assuming 99% removal of particulates by electrostatic precipitators and cyclones.*
9. *Based on emission rates observed in 1977 (Hills 1978).*

florescence and atomic absorption spectroscopy. The full results are given in Appendix B. Concentrations of all of the elements were very low, usually below detection limits. Upper limits for annual emissions for selected elements are given in Table 3.2.1-D. Since these elements are generally associated with very fine particles for which collection efficiencies of control equipment are reduced, only a 90 percent removal rate is assumed in computing controlled emissions.

The combustion of wood, especially by low temperature pyrolysis, produces hydrocarbons that may be mutagenic and carcinogenic. The high temperatures in the boiler and overfired oil burning will ensure incineration of most pyrolysis products. Hydrocarbons that escape incineration will tend to adhere to particulates and therefore be removed by the particulate emission control system. The amount of hydrocarbons emitted should be verified by monitoring when the plant is in full operation.

Net Changes in Emissions of Criteria Air Pollutants

When the proposed wood-fired power plant becomes operational and the boilers currently operating at the S.D. Warren Company mill are decommissioned, significant changes in the emissions of criteria air pollutants from the mill complex will occur. These changes are shown in Table 3.2.1-E for three likely operating conditions: the proposed wood-fired boiler operating with S.D Warren Company's #20 boiler at full capacity under normal conditions; the proposed wood-fired boiler operating alone at full capacity under normal conditions; and the proposed wood-fired boiler operating in emergency mode and firing 0.7 percent sulfur content oil as its entire fuel input. "Normal" operating conditions for the wood-fired boiler means the firing of 98.5 percent wood and 1.5 percent Number 6 oil, while the incoming wood is predried. The baseline condition against which these changes are compared is S.D. Warren Company's normal full capacity operation of its existing boiler system.

As shown in Table 3.2.1-E, normal operation of the proposed wood-fired boiler will result in a net reduction in emissions of particulates, sulfur dioxide, and hydrocarbons. Total emissions

TABLE 3.2.1-D: TRACE METALS IN WOOD-FIRED BOILER EMISSIONS

Metal	Emission Rate[1] (lbs per year)
Copper	78
Arsenic	<49
Selenium[2]	<134
Lead	<10
Cadmium	<10
Nickel	205
Chromium	<5
Vanadium	<246
Beryllium[3]	84

1. *Based on trace element composition of wood (see Appendix B) and oil (see Appendix C). Assumes 350 days per year operation, oil consumption not greater than 4% on a Btu-input basis, 70% of ash is flyash, and 90% particulate removal.*
2. *Assumes 13% of selenium in wood is discharged to the atmosphere as a vapor (Dvorak et al. 1977).*
3. *Assumes beryllium content of wood is equivalent to that of coal (Dvorak et al. 1977).*

TABLE 3.2.1-E: NET CHANGES IN EMISSION OF CRITERIA POLLUTANTS AT THE WESTBROOK SITE UNDER VARIOUS OPERATING CONDITIONS[1]

	Emissions (tons/year)				
	Total Suspended Particulates	Sulfur Dioxide	Nitrogen Dioxide	Hydro-carbons	Carbon Monoxide
Normal Operation[2]	-380	-7,170	+660	-260 to -10	+180 to +420
Normal Operation plus #20 Boiler	-240	-4,840	+1,030	-250 to -3	+210 to +450
Emergency Oil-only Operation[3]	-700	-5,840	-580	-310 to -64	-340 to -100

1. *The figures for each operating mode assume that this mode prevails for the entire operating year. In reality, normal operation, with and without Boiler #20, will prevail most of the time, with Boiler #20 operating as a swing boiler. Oil-only operation will apply only in emergency conditions and in no case for more than 4% of the operating year. Figures are derived from the difference between current S.D. Warren emissions (shown in Table 14) and estimated emissions from the wood-fired facility (shown in Table 15) under various operating modes.*
2. *Plant operating on 98.5% wood and 1.5% oil with full wood drying.*
3. *Fuel oil 0.7% sulfur in this mode, 2.1% in all other modes.*

of nitrogen oxides and carbon monoxide will be greater than those from the current boilers. The emission rates for carbon monoxides from the boilers and the proposed wood boiler are not well known, and the exact magnitude of the change is difficult to quantify. If it turns out that the increase is greater than 250 tons per year, an ambient air quality monitoring program may be required by the U.S. Environmental Protection Agency prior to construction of the proposed plant to ensure that applicable air quality standards will not be threatened. In the emergency oil-firing mode of operations, net emissions of all five pollutants will decrease. However, the oil-firing mode will be used only about 4 percent of the operating year.

Because the proposed wood-fired boiler will operate at the same rate throughout the year and the present Warren boilers operate at greater capacity in winter than in summer, the actual emission decreases will be less than indicated and net emission increases will be greater than indicated in the summer.

Worst-case Impacts from Existing and Proposed Sources

Maximum ground-level concentrations of four criteria pollutants to be emitted from the proposed power plant were computed using the Environmental Protection Agency's PTMAX air dispersion model (see Appendix B) for various combinations of wind speed and atmospheric stability class. This analysis determined that plume looping resulted in the highest short-term average pollutant concentrations close to the source of emissions. Second highest concentrations were found during conditions of an elevated temperature inversion. In the latter case, increased ground-level concentrations of pollutants result from a reduction in the volume of air in which pollutants may dissipate.

The actual frequency of occurrence of these worst case conditions at ground level was estimated from data from the nearby Portland Jetport (NOAA 1978). Looping conditions occur during the summer for a total of about seven mid-day hours. The elevated temperature inversion occurs a much greater percentage of the time, perhaps up to 218 hours per year (see Appendix B). Impact patterns for the existing and proposed plumes were predicted using

the Environmental Protection Agency's PTDIS model (see appendix B) under these two meteorological conditions. Spatial distributions of hydrocarbon concentrations were not computed since hydrocarbon emissions are considered important only when they contribute regionally to area-wide ozone levels.

Impact during looping conditions. During meteorological conditions favorable to looping, the maximum ground-level impact of any pollutant due to operation of the existing S.D. Warren Company boilers occurs at a distance of 0.8 kilometers from the stack. The maximum impact of the wood-fired boiler operating alone or jointly with the existing boiler #20 under these same conditions would occur at 0.7 to 0.8 kilometers downwind. The greatest net change in air quality is observed at about one kilometer.

The wood-fired boiler emits very little sulfur dioxide, and joint operation with boiler #20 will result in a substantial reduction in maximum one-hour sulfur dioxide concentrations at 0.8 kilometer from the stack. Further away from the stack, sulfur dioxide impacts will also be reduced, although the net change will diminish considerably. For total suspended particulate concentrations, joint operation will result in a slight increase (3 μg/cu m) in short-term ground-level impacts at 0.8 kilometers. Beyond this distance, impacts from the proposed source will very closely resemble those from current boiler operations.

Operation of the proposed boiler during looping conditions similarly will result in increased short-term ground-level concentrations of carbon monoxide. The magnitude of this net increase cannot be precisely determined because of the uncertainty associated with the existing bark boiler emission factor.

Impact during elevated inversion conditions. During meteorological conditions of elevated inversion, the distance to the maximum ground-level impact of the existing boilers is about 6 kilometers, that of the proposed boiler will be approximately 4.5 kilometers, and that of joint operation with boiler #20 will be 3 to 5 kilometers. During these meteorological conditions, the greatest net short-term change will be a substantial improvement in one-hour sulfur dioxide concentrations at six kilometers. Total

TABLE 3.2.1-F: AMBIENT AIR QUALITY STANDARDS AND MAXIMUM IMPACT UNDER ADVERSE CONDITIONS

		National Air Quality Standards		Maine Air Quality Standards	Maximum Impact Under Looping Conditions		Maximum Impact With Elevated Inversions	
Pollutant	Averaging Time	Primary[1] Standards	Secondary[2] Standards		Normal Operation	With Boiler #20	Normal Operation	With Boiler #20
Sulfur Dioxide	Annual arithmetic mean	80 µg/cu m (0.03ppm)		57 µg/cu m				
	24 hours[3]	365 µg/cu m (0.14ppm)		230 µg/cu m	20 µg/cu m	160 µg/cu m	12 µg/cu m	74 µg/cu m
	3 hours	--	1300 µg/cu m (0.5ppm)	1150 µg/cu m				
Particulates	Annual geo-metric mean	75 µg/cu m	60 µg/cu m	50 µg/cu m				
	24 hours[3]	260 µg/cu m	150 µg/cu m	100 µg/cu m	14 µg/cu m	22 µg/cu m	6 µg/cu m	10 µg/cu m
Carbon Monoxide	8 hours[3]	100 µg/cu m (9ppm)	Same as primary	100 µg/cu m				
	1 hour[3]	400 µg/cu m (35ppm)		400 µg/cu m	28 µg/cu m	29 µg/cu m	11 µg/cu m	12 µg/cu m
Lead	Quarterly Mean	1.5 µg/cu m	--	--				
Hydrocarbons (corrected for methane)	3 hours[3]	160 µg/cu m[4] (0.24ppm)	Same as primary	160 µg/cu m				
Nitrogen Dioxide	Annual arithmetic mean	100 µg/cu m	Same as primary	100 µg/cu m	85 µg/cu m	105 µg/cu m	37 µg/cu m	47 µg/cu m
Ozone	1 hour[3]	235 µg/cu m	Same as primary[5]	--				

1. *National primary standards determine the levels of air quality necessary, with an adequate margin of safety, to protect the public health.*
2. *National secondary standards determine the levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.*
3. *National and state standards not to be exceeded more than once per year.*
4. *Guideline to be used in assessing implementation plans.*
5. *Standard expected to be adopted (MDEP 1979).*

Source: CFR 1977; FR 1978; FR 1979; MDEP 1977).

suspended particulate concentrations will decrease minimally. Nitrogen dioxide levels will increase moderately at 4 kilometers, the distance of maximum impact of nitrogen dioxide for joint operation. The net change in predicted concentrations diminishes more slowly with distance than for the looping analysis, and is still significant at a distance of 10 kilometers.

One-hour carbon monoxide levels resulting from joint operation during elevated inversions will not differ significantly from concentrations predicted for the existing boilers.

In summary, these results indicate that even during certain meteorological conditions unfavorable to pollutant dispersal, significant decreases in sulfur dioxide concentrations will result from the changeover of current boilers to the proposed biomass boiler. Maximum short-term ground-level impacts of total suspended particulates and carbon monoxide will not change substantially. Nitrogen dioxide concentrations will increase significantly during such meteorological conditions.

The expected ground-level impacts from the proposed plant for any pollutant under either meteorological condition are far below the appropriate short-term ambient air standards (see Table 3.2.1-F). In addition, the calculated impacts of sulfur dioxide and total suspended particulates do not approach the short-term Environmental Protection Agency Prevention of Significant Deterioration (PSD) Air Quality Increment Standards for Class II regions (see Appendix B). No PSD Standards exist for either nitrogen dioxide or carbon monoxide.

Impact during fumigation conditions. A third plume phenomenon known as fumigation may occur during meteorological conditions of a stable atmosphere with low wind speeds. During fumigation, a plume emitted into a stable layer aloft is rapidly mixed to the ground when unstable air from below reaches the plume. Conditions conducive to fumigation may occur quite frequently at the Westbrook site (Ramsdell 1961). Maximum fumigation impact for the existing boilers is 19 kilometers downwind of the stack, while that from the proposed boiler is roughly 12 kilometers away. The magnitude of the impact for each pollutant is listed in Table

3.2.1-G. The magnitudes of the maximum impacts are quite similar to those observed in the looping analysis. Lesser impacts will occur at locations nearer the stack. Thus, for commonly occurring westerly winds, these impacts will occur in downtown Portland and over the ocean. Also as with the other analyses, maximum concentration of pollutants other than nitrogen dioxide due to operation of the wood-fired boiler alone under normal conditions are very low. The data suggest that the total impact of joint operation would be less than that for the existing S.D. Warren Company boiler for sulfur dioxide and particulates.

Changes in Annual Average and Short-Term Ambient Air Quality

The CRSTER model (see Appendix B) was used to estimate the highest annual mean and maximum 1-hour, 3-hour, and 24-hour concentrations for several criteria pollutants resulting from operation of the present S.D. Warren Company boilers and from operation of the proposed wood-fired power plant. As S.D. Warren Company's existing #20 boiler will operate as a swing boiler after the wood boiler is built, the ambient air impacts of operating boiler #20 with the wood-fired boiler were also determined. The impacts of operating boiler #20 alone are provided to help identify the source of the combined impacts. Results of these analyses are summarized in Table 3.2.1-H. The concentrations calculated are due solely to operation of boilers at the mill site. Background concentrations are not considered, and the calculated concentrations should not be misconstrued as ambient concentrations.

Furthermore, each indicated concentration applies only to the single receptor site with the maximum concentration. At each of the other 179 receptors, therefore, computed concentrations were less, often much less. As the receptor locations were chosen to be sites of expected maximum impacts, the indicated maximum concentrations are considered to be true maxima for the entire region. Lastly, the maximum short-term concentrations predicted by CRSTER occur as the result of short-lived worst-case meteorological conditions, as recorded in the year 1964, and concentrations for the rest of the year are therefore lower.

TABLE 3.2.1-G: FUMIGATION ANALYSIS OF PROPOSED PLANT UNDER VARIOUS OPERATING CONDITIONS

Operation Mode	Distance to Maximum Impact (*km*)	Pollutant Concentration (*μg/cu m*) Total Suspended Particulates	Sulfur Dioxide	Nitrogen Dioxide	Carbon Monoxide
Normal Operation	12	13	15	79	25
Emergency Oil-only Operation	13	5.1	70	28	3.2
Boiler #20 Only	13	5.7	97	16	1.4
Current S.D. Warren Boilers: Full capacity	19	19	200	34	4.7 to 11

From Table 3.2.1-H it can be seen that the impact of the proposed wood-fired boiler on ground level ambient air quality will be small for sulfur dioxide, total suspended particulates, nitrogen dioxide, and carbon monoxide. When the new wood-fired system is operating alone, the resulting maximum annual and short-term concentrations of any pollutant will be very much lower than the applicable ambient air quality standard. The highest annual mean concentration and maximum short-term concentrations of sulfur dioxide will be substantially reduced over those currently caused by S.D. Warren Company's existing boiler system. Ambient particulate concentrations will not change significantly when the proposed wood-fired system replaces the existing boilers; the highest annual mean and 24-hour concentrations will remain the same or will slightly decrease, while the highest 3-hour and 1-hour concentrations will increase slightly. Annual ground-level impacts of nitrogen dioxide are roughly twice those of the present boilers, although the concentration is still only 1 percent of the ambient standard. Maximum concentrations of carbon monoxide due to operation of the wood-fired boiler may be five times higher than those due to existing boilers. The resulting concentrations, however, will only be about one one-thousandth of the applicable air quality standard.

Operation of boiler #20 with the proposed wood-fired boiler will cause greater air quality impacts than will the proposed boiler operating alone. The modeled impact of boiler #20 for each pollutant on ground-level ambient air quality is surprisingly similar to that of the entire existing boiler complex, despite the much lower levels of total emissions (see Table 3.2.1-B). The magnitude of this impact is high because #20 operating alone will have a very low stack gas volume and a small plume rise.

Consequently, sulfur dioxide levels resulting from operation of the mill complex are expected to be nearly unchanged in the changeover to the new boiler configuration. Annual and 24-hour particulate concentrations similarly remain about the same, although concentrations for shorter averaging times do increase

TABLE 3.2.1-H: ESTIMATED GROUND-LEVEL AMBIENT AIR QUALITY IMPACTS OF PROPOSED WOOD-FIRED FACILITY UNDER VARIOUS OPERATING CONDITIONS*

	Normal Operation			Boiler #20 Only			Wood-fired + #20 Boilers			Current S.D. Warren Boilers		
	Concentr. (µg/cu m)	Dir.[3]	Dist.[4]	Concentr. (µg/cu m)	Dir.[3]	Dist.[4]	Concentr. (µg/cu m)	Dir.[3]	Dist.[4]	Concentr. (µg/cu m)	Dir.[3]	Dist.[4]
TOTAL SUSPENDED PARTICULATES												
Highest annual mean[1]	0.18	1	6.5	0.08	1	6.5	0.27	1	6.5	0.13	1	6.5
Highest 24-hour[2]	2.1	1	6.5	0.88	28	1.2	2.8	1	6.5	2.2	1	6.5
Highest 3-hour[2]	12	1	6.5	6.4	36	1.2	16	1	6.5	8.6	1	6.5
Highest 1-hour[2]	28	1	6.5	11	1	6.5	37	1	6.5	18	28	2.4
SULFUR DIOXIDE												
Highest annual mean[1]	0.21	1	6.5	1.4	1	6.5	1.6	1	6.5	2.0	1	6.5
Highest 24-hour[2]	2.4	1	6.5	15	28	1.2	17	28	1.2	24	1	6.5
Highest 3-hour[2]	14	1	6.5	110	36	1.2	110	36	1.2	94	1	6.5
Highest 1-hour[2]	32	1	6.5	180	1	6.5	210	1	6.5	200	28	2.4
NITORGEN DIOXIDE												
Highest annual mean[1]	1.1	1	6.5	0.22	1	6.5	1.3	1	6.5	0.34	1	6.5
Highest 24-hour[2]	13	1	6.5	2.4	28	1.2	15	1	6.5	4.1	1	6.5

TABLE 3.2.1-H: CONT.

	Normal Operation			Boiler #20 Only			Wood-fired + #20 Boilers			Current S.D. Warren Boilers		
	Concentr.	Dir.[3]	Dist.[4]	Concentr.	Dir.[3]	Dist.[4]	Concentr.	Dir.[3]	Dist.[4]	Concentr.	Dir.[3]	Dist.[4]
Highest 3-hour[2]	73	1	6.5	18	36	6.5	82	1	6.5	16	1	6.5
Highest 1-hour[2]	170	1	6.5	29	1	6.5	190	1	6.5	34	28	2.4
CARBON MONOXIDE												
Highest annual mean[1]	0.35	1	6.5	0.02	1	6.5	0.37	1	6.5	0.05-0.11	1	6.5
Highest 24-hour[2]	3.9	1	5.5	0.21	28	1.2	4.1	1	6.5	0.57-1.3	1	6.5
Highest 8-hour[2]	-	-	-	-	-	-	12	1	6.5	-	-	-
Highest 3-hour[2]	23	1	6.5	1.6	36	1.2	23	1	6.5	2.2 - 5.3	1	6.5
Highest 1-hour[2]	53	1	6.5	2.6	1	6.5	54	1	6.5	4.7-11	28	2.4

* *Estimates from U.S. Environmental Protection Agency's CRSTER model.*

1. *The highest annual mean concentration recorded at any one of the receptors.*
2. *The highest concentration recorded at any one of the receptors for any of the averaging periods.*
3. *Measured in 10^{o} compass increments clockwise (east) from due north: 1 = 10^{o} east of due north, 2 = 20^{o}, etc.*
4. *Measured in kilometers from the emission source to receptor.*

slightly. Nitrogen dioxide concentrations for shorter averaging times increase, and are due primarily to operation of the wood-fired boiler. Resulting annual concentrations may increase by a factor of three to five over those resulting from the existing plant. These levels are well below the annual ambient air quality standard, the only standard for nitrogen dioxide. Carbon monoxide levels during joint operation of the wood-fired boiler and boiler #20 are very similar to those calculated for operation of the proposed wood-fired boiler alone. While the calculated impacts do increase, resulting concentrations remain far below ambient air quality standards.

In general, increased ground-level concentrations of nitrogen dioxide and carbon monoxide are due to operation of the wood-fired boiler. Sulfur dioxide levels primarily reflect operation of boiler #20 and particulate levels are due to both boilers. The ground-level concentrations of sulfur dioxide and particulates resulting from joint operation of the wood-fired boiler and the #20 boiler could be substantially reduced by exhausting the #20 boiler's emissions through the wood-fired boiler's stack.

The maximum impacts for all operating cases are consistently in the region of elevated terrain several kilometers to the north of the plant site. This is a relatively sparsely populated area. Lower concentrations are observed in the more heavily populated regions of metropolitan Portland, east of the plant site.

The Environmental Protection Agency's PSD air pollutant increments for sulfur dioxide and total suspended particulates for Class II areas will not be threatened. No such increments exist for nitrogen dioxide and carbon monoxide.

Conclusion. Operation of the proposed wood-fired boiler and #20 boiler will result in significant reductions in emissions of total suspended particulates, sulfur dioxide, and hydrocarbons. Because of the low exit flow rate of the plume from boiler #20 operating in the existing S.D. Warren Company stack, this decrease in emissions does not lead to a corresponding decrease in ground-level ambient air concentrations of these pollutants. Increased nitrogen dioxide emissions due mainly to operation of the wood-

fired boiler do not threaten ambient air quality standards. Increased emissions of carbon monoxide at the site will produce increases in ground level concentrations which are negligible in comparison to accepted air quality standards for carbon monoxide.

A projection of the actual ambient air quality to be expected in the region around the new wood-fired boiler requires a detailed knowledge of the existing air quality as well as the computer-generated projections of impacts from the new boiler. Ambient air concentrations depend heavily on local emission sources, even small ones, and on daily meteorological conditions. Thus, the determination of present ambient air quality must be carried out at a number of sites for periods of several months to several years. These data have never been generated for Westbrook.

Because the projected changes in atmospheric concentrations resulting from the substitution of the new wood-fired boiler for the old bark and oil boilers were low or negative for sulfur dioxide, total suspended particulates, and carbon monoxide, an extensive neighborhood monitoring program for these pollutants was not warranted. Similarly, the net decrease in hydrocarbon emissions indicates that ambient ozone levels will not increase, and may decrease. The condition of the present ambient air quality indicates that, except for ozone, air quality standards designed to protect the public health are not presently threatened. Computer modeling indicates that the change in air quality due to the plant will be slight, and that an improvement in air quality will be observed for certain pollutants at many locations. It is concluded, therefore, that the projected air quality (except for ozone) will continue to be within levels considered important for the public health and welfare.

3.2.2 Hydrology and Water Quality

Water Supply

The proposed wood-fired boiler and related facilities at Westbrook will require the use of water for steam generation, ash sluicing, the cooling tower, blowdown to prevent sediment buildup in the cooling tower and boilers, and waste transport. Table

3.2.2-A shows the breakdown of the water consumption according to intended use. An average demand of 1,191 gallons per minute (gpm) is anticipated. Of this only 200 gpm will be returned to the river as discharge from the ash ponds. The remaining 991 gpm will be lost as evaporation in the cooling towers or become part of the S.D. Warren plant water flow. This water will be extracted from the Presumpscot River at the same point currently used by the S.D. Warren Company; no new extraction facilities will be required (Manar 1978d).

At present, the S.D. Warren Company uses approximately 17,361 gpm of which 15,972 come from the Presumpscot River (S.D. Warren 1978). Of this total, 52 gpm are used for boiler blow-down (S.D. Warren 1978) for boilers #16, #17, and #18 which will no longer operate when the wood-fired boiler comes on line. The operation of the proposed facility will therefore, result in a net increase of 1,139 gpm in water use from the Presumpscot River. This represents approximately 0.25 percent of the mean discharge of the river and approximately 5 percent of the lowest discharge during the July closedown period. However, because this period of low discharge results from closing the control gates at Sebago Lake, additional water could be released to compensate for the increased water use and to maintain water quality. At present, S.D. Warren Company does not operate during the closedown period.

An exception to this use of Presumpscot River water may occur when increased suspended sediment and/or color of the river water prohibits its use in the S.D. Warren process plant. At such times, the purchase of water from the Portland Water District will temporarily replace the ordinary supply; this occurs now from time to time. The need for municipal water occurs primarily after major storm events, when urban runoff sharply increases in magnitude and carries sediment from watershed erosion with the surface waters. The occurrence of such episodes is related to weather and land use and should not be altered by the proposed project.

TABLE 3.2.2-A: PROJECTED WATER USE OF WOOD-FIRED POWER PLANT

USE	GALLONS PER MINUTE
Cooling Tower Makeup Water	
Evaporation	200
Windage	5
Blowdown[1]	20
To S.D. Warren (Prior to Boiler)	200
To Boiler	
Steam to turbine: feedwater makeup	586
Boiler blowdown [1]	14
Activated Carbon Filter, Dimineralizer Wastes	50
Ash Sluicing (make up to ash sluice surge tank)	116
TOTAL	1,191

1. *Blowdown refers to the volume of water discharged to avoid the increased concentration of dissolved solids resulting from evaporation.*

Source: Mondragon 1978.

Water Quality

The proposed plant would not require the installation of new points of discharge into any bodies of water. The existing discharge point from S.D. Warren Company's water treatment system into the Presumpscot River would be employed. Wastewater flows projected to be generated by the new facility are shown in Table 3.2.2-B. The projected average discharge from the plant is 200 gpm. These wastes would be channeled into the process sewer and secondary treatment plant operated by the S.D. Warren Company. The present rate of wastewater discharge from the secondary treatment plant into the Presumpscot River is 11,163 gpm, which includes 52 gpm from the boilers to be replaced. The proposed wood-fired power plant with a discharge of 200 gpm would result in a net increase of 148 gpm in wastewater from the site.

At present, the S.D. Warren Company reduces the flow of the Presumpscot River during July in order to maintain its facilities. If the wood-fired boiler were operated to produce electricity during this period, water discharges would be retained in the ash ponds if necessary to maintain adequate water quality in the river.

Before the startup of the plant and every five years after that, the new boiler will be cleaned with hydrochloric acid solution (Mondragon 1978). A total volume of 210,000 gallons of the solution will be used during each cleaning. Rather than being discharged directly into the treatment plant where the acidic shock could kill the decomposing bacteria necessary for treatment, these wastes would be emptied into the ash ponds where they will be diluted with the basic (pH 11) ash wastes produced under normal operation (Manar 1978e).

A further source of wastewater is the surface runoff generated by precipitation at the plant site. Most of the proposed plant site is presently paved and has a sewer connection with the S.D. Warren secondary treatment facility. In these areas no new runoff should occur and water quality should not deteriorate. The proposed chip pile area of the S.D. Warren property is unsewered, and surface water runs off to the Presumpscot River. Problems might occur if water leaching through, or generated within, the

TABLE 3.2.2-B: PROJECTED WASTEWATER FROM THE WOOD-FIRED POWER PLANT

SOURCE	GALLONS PER MINUTE
Cooling tower blowdown	20
Activated carbon filter, demineralizer wastes (average)	50
Boiler blowdown	14
Fly ash precipitator	350
Intermittent ash sluice (average)	150
Makeup water to ash sluice surge tank	116
Total to Ash Ponds	700
Recycle	-500
Discharge from Ash Pond	200

chip pile was allowed to run off freely. To avoid this, all leachate will be collected and conduited to the ash pond to await secondary treatment along with other wastewaters (Manar 1978e).

At present, the U.S. Environmental Protection Agency is formulating Best Management Practices for the handling of wastewaters resulting from storage piles and other ancillary operations of wood products processing. Standards have not been established for wood chip piles (Thron 1978), but it is likely that secondary treatment, as will be practiced at the proposed wood-fired plant, will be determined to be a Best Management Practice (Dellinger 1978). Table 3.2.2-C gives the projected effluents from all sources at the wood-fired power plant and the changes in discharge that would result from the use of the plant as a replacement for existing boilers at S.D. Warren. The power plant discharge is alkaline and high in potassium, sulphate, silica and calcium. When this discharge is released into the S.D. Warren wastewater treatment system it would be diluted over 500 times in the overall wastewater flow of the entire mill complex. There should be no effect on the biological action of the treatment plant. All the constituents of the power plant discharge, with the exception of biological oxygen demand, are conservatively assumed to pass through the plant unaffected. Table 3.2.2-D gives the projected changes in water quality in the Presumpscot River that would result from the operation of the new facility. The changes in water quality in the river are so small that they are below the level at which a change can be reliably detected. These changes will not significantly affect the quality of the Presumpscot River and should not affect its classifications or present uses.

The discharges from this plant would not prevent the river from meeting the requirements for a higher classification if bacterial and organic pollutants from other sources were reduced.

Because the Presumpscot River is under consideration for classification as a cold-water fishery, the water discharge from the plant is not allowed to cause the temperature of the river to exceed 68^{o}F. To comply with these requirements the new plant will include an induced mechanical draft cross-flow type cooling

TABLE 3.2.2-C: PROJECTED EFFLUENT COMPOSITION OF THE WOOD-FIRED POWER PLANT

	Plant Effluent *(pounds per day)*	Changes in Final Discharge to River [1] *(pounds/day)*
Silica as SiO_2	168.0	+64
Calcium as CaO	134.0	-358
Magnesium as MgO	39.0	+37
Iron as Fe_2O_3	10.0	-12
Aluminum as Al_2O_3	10.0	+9.3
Sodium as Na_2O	74.0	-188
Pottasium as K_2O	490.0	+489
Sulphate as SO_4	360.0	+303
Chloride as Cl	72.0	-18
Phosphate as PO_4	8.0	+21
Manganese as MnO	5.0	+5
Titanium as TiO_2	trace	-0.7
Vanadium as V_2O_5	trace	$\leq$-0.73
Nickel as NiO	trace	<+0.024
Zinc as ZnO	2.0	<+2.0
Suspended Solids	100.0	+6
Hydroxic (O-H)	312.0*	NA
Carbonate (CO_3)	192.0*	NA
Biological Oxygen Demand	28.0	4.2
Total PH	11.4	Unchanged

1. Discharges from proposed plant minus discharges from S.D. Warren boilers to be closed down. Biological demand is reduced at least 85 percent in the treatment plant before discharge. All other constituents are assumed to pass through the treatment plant virtually unaffected, although small reductions may occur in some compounds.

Source: Murphy 1980

* *These alkalinity conditions could change when the wastewater is passed through a biological treatment process.*

NA = Data not able to estimate change but change would be very small.

TABLE 3.2.2-D: PROJECTED CHANGES IN PRESUMPSCOT WATER QUALITY AS A RESULT OF PROPOSED FACILITY[1]

	Current Average Concentration[2] *(milligrams/liter)*	Average Change During Operation[3] *(milligrams/liter)*
Silica	NA	+0.005
Calcium	4.32	-0.03
Magnesium	0.69	+0.004
Iron	0.49	-0.001
Aluminum	0.38	+0.001
Sodium	2.85	-0.02
Pottasium	1.03	+0.064
Sulphate	5.19	+0.055
Chloride	5.58	-0.003
Phosphate	0.04	+0.001
Manganese	0.014	+0.0005
Titanium	0.006	+0.00006
Vanadium	NA	-0.00006
Nickel	0.003	trace
Zinc	0.057	+0.0002
Suspended Solids	NA	+0.00001
Biological Oxygen Demand	NA	+0.00001

NA = data not available.

1. *Assumes mean flow of 1,167 cubic feet/second for Presumpscot River. See note 1, Table 3.2.2-C.*
2. *Source: S.D. Warren 1978.*
3. *Calculated from column 2 in Table 3.2.2-C.*

tower. Further heat will dissipate in the ash pond and treatment plant before the water is discharged to the river.

Flooding of the Presumpscot River should not pose any water quality problems beyond those which presently exist. The ash pond and chip pile are the only facilities that contain potential contaminants that would be released by flood waters. The base of the chip pile will lie at an elevation of sixty-seven feet. The ash pond is to be contained within a dike, the top of which will be at an elevation of forty-five feet. The one-hundred-year flood (the maximum flood expected to recur once every one hundred years) rises to an elevation of 43.5 feet (Manar 1978e). The new facilities should be outside the reach of any flood with a predicted recurrence interval of one hundred years or less.

Groundwater contamination could occur only from the wood chip pile and ash pond. Leachate from the former will be avoided by the collection of all drainage for treatment. Water from the ash pond will also be treated. On nearby areas of the S.D. Warren property, ground cores have shown the water table to occur at depths as low as two feet three inches (Gorrill 1969) and five feet six inches (MTB 1977). However, there will be no contamination of the ground water from the ash pond, as the base will be on an impervious clay layer and the sides of the ash pond will be lined with impervious clay (Manar 1978b). During construction, the local water table will be temporarily drawn down to permit sealing of the ash pond clay lining.

The composition of ash and wastewater discharge will vary with the chemical composition of the fuelwood supply and operational characteristics of the boiler. The project will provide an opportunity for monitoring the composition of the ash and wastewater with various fuel mixtures of wood, bark, and oil and under varying operational modes of the boiler.

3.2.3 Terrestrial Ecosystems

Impacts of the proposed wood-fired power plant project on terrestrial ecosystems will result from the construction of the

new facility and from harvesting wood to fuel the wood boiler system. These impacts are discussed in Sections 3.1.3 and 3.3.4, respectively. No noticeable impacts on terrestrial ecosystems will occur solely as a result of operation of the new facility. Replacement of S.D. Warren's existing oil-fired system with the wood system will cause only slight changes in air quality in the Westbrook area (see Section 3.2.1). No noticeable change in plant or animal life will occur as a result.

The new plant will release less wastewater and heat into the Presumpscot River than the current facility, and there will be small changes in the chemical characteristics of the effluent (see Section 3.2.2). These changes in water quality will have no impact on river-bank ecosystems.

3.2.4 Aquatic Ecosystems

The increase in water extraction will represent approximately 6.5 percent of present extraction levels and approximately 0.25 percent of the mean flow of the Presumpscot River. This increase will slightly increase the quantity of plankton, invertebrates, and juvenile fish removed from the river.

Water quality changes in the Presumpscot River resulting from the operation of the proposed facility will be extremely small and will have limited effects on the aquatic environment. Heavy metals present in the wastewater discharge may accumulate in the tissues of aquatic organisms (Dvorak et al. 1977). These elements may be concentrated to levels several orders of magnitude above the ambient conditions. Bioaccumulation is generally greatest among phytoplankton and aquatic invertebrates and lowest in fish. Higher organisms, however, are most susceptible to the magnification of trace elements through the food chain. In addition, the synergistic effects of combinations of trace elements nd changes in pH can alter toxicity thresholds. The operation of the proposed wood-fired power plant will result in changes in the discharges of heavy metals. Vanadium discharges will be reduced by at least 30 percent, while nickel and zinc discharges will be

slightly increased. There may also be trace quantities of copper, chromium, titanium, arsenic, lead and cadmium in the ash pond wastewater. Although the effects of chronic, low-level exposure to these substances are not well understood, the significance of these discharges in comparison with the existing operation will be negligible.

The discharges resulting from the operation of the plant are not expected to have any significant effect on the riparian ecosystems of the Presumpscot River. No endangered aquatic species will be affected. The lower Presumpscot River is not generally used for sport or commercial fishing.

3.2.5 Land Use Impacts

Operation of the proposed wood facility will have few direct or indirect impacts on land use in the surrounding community. The sale of excess electrical energy to the Central Maine Power Company will not necessitate expansion of current transmission rights-of-way (see Section 3.6). In addition, an existing Greater Portland landfill will accommodate wood ash disposal for one and one-half to two and one-half years (see Section 3.2.6). There will be an incremental effect on landfill capacity and hence an indirect effect on land use.

The replacement of S.D. Warren's existing oil and bark boilers with a wood waste boiler will not noticeably change air quality throughout Westbrook (see Section 3.2.1). The visibility of air pollutant emissions will decrease slightly. Steam emissions are discussed in Section 3.2.8. The desirability of locations for residential, commercial, or recreational activities will not be affected.

The proposed plant will have no visual or olfactory impacts on the Presumpscot River (see Section 3.2.2). Land use along the Presumpscot's banks will not be altered as a result of water resource impacts.

S.D. Warren's labor requirements during new plant operations will nearly equal current labor requirements, and impacts on the

local economy will be negligible (see Section 3.2.7). Residential and commercial acreages will therefore not be influenced by operation of the proposed power plant. Although ambient noise will increase somewhat in the residential area west of the proposed plant site (see Section 3.2.8), the community has, in the past, had much experience with high noise levels produced by the S.D. Warren mill (see Section 2.1.9). Community reaction will be minimal (estimated from Eldred 1971), and land use patterns will therefore not be affected.

Between eighty-five and one hundred trucks carrying fuelwood will arrive at and leave the proposed facility each day (see Section 3.5.1). These trucks could have an impact on land use patterns along truck routes. At present, the precise routes these trucks will follow into Westbrook are unknown. The routes and the number of trucks traveling each route will vary, however, with fuelwood source locations.

Maine Route 25, U.S. Routes 2, 202, and 302, Interstate 95, and the Maine Turnpike are likely to be the routes most heavily traveled by trucks carrying fuelwood. Adding up to one hundred trucks to the current traffic flow of any of these routes will result in a small percentage increase in total traffic (see Section 3.5.3). This fact, coupled with the fact that development along these routes is largely commercial and industrial, minimizes the potential for land use impacts. The noise and congestion produced by additional truck traffic, however, could encourage the replacement of residential land along sections of Routes 25, 202, and 302 with other uses.

Construction of a chip pile access road off Park Road (see Section 3.5.3) will introduce a higher volume of truck traffic into the low-density residential district north and west of the plant site. Congestion and noise will increase, traffic safety will decrease, and the area's overall residential appeal could decline slightly. Multi-unit residential, commercial, or industrial land uses could partially supplant established uses.

3.2.6 Ash Disposal Impacts

Combustion of fuelwood and oil in the proposed boiler will produce about eighty tons of ash per day (Manar 1978c). This amount of ash will occupy a volume ranging from 136 cubic yeards of up to 50% moisture content to 336 cubic yards at 300% moisture content. Ash will be transferred from the boiler to settling ponds in a wet slurry. Two settling ponds will be used; one will receive ash while the other is drying and then being emptied. The ash ponds will be lined with impervious clays and no adverse surface or ground water impacts are expected (see Section 3.2.2). Ash ponds will freeze in winter. The ponds will be designed with sufficient depth to allow ash accumulation to continue during the winter. Ash removal will be scheduled during the period when the ponds are unfrozen. Ash drying will occur during the summer months when evaporation exceeds precipitation. Final ash disposal arrangements have not been made at this stage of the project so a detailed analysis of impacts from that portion of the operation is not possible. It is expected that during the first one and one half to two and one half years, the ash will be disposed of in an existing landfill operated by the S.D. Warren Company at Scarboro, Maine. The Scarboro landfill is approved by the Maine Department of Environmental Protection for the disposal of wood and bark boiler ash (Labrecque 1979). Site-specific impacts of disposal at other locations will be conducted after appropriate sites have been identified. Opportunities for marketing the ash are also being investigated.

The estimated composition of the ash is given in Table 3.2.6-A. The heavy metal concentrations are highly sensitive to the composition of the wood and oil used and the percentage of oil consumed on an annual basis. Concentrations shown in Table 3.2.6-A are based on a maximum annual fuel oil consumption of 4 percent on a Btu input basis. There will be a net reduction of at least 30 percent in the amount of heavy metals (mainly vanadium) disposed of in the landfill (Manar 1979c).

Any leachate from the ash in a landfill will have chemical constituents similar to the water discharge from the ash ponds which is discussed in Section 3.2.2. If the ash is properly land-

TABLE 3.2.6-A: ESTIMATED ASH COMPOSITION[1]

MAIN COMPONENTS

Element	as Compound	Percent of Weight
Silica	SiO_2	17.0
Aluminum	Al_2O_3	5.6
Iron	Fe_2O_3	3.4
Calcium	CaO	28.7
	$CaCO_3$	6.5
Magnesium	MgO	7.3
Manganese	MnO	2.6
Phosphorus	P_2O_5	6.3
Potassium	K_2O	14.0
Sodium	Na_2O	3.9
Sulfur	SO_3 --	3.7
Chlorine	Cl -	≤1.0

TRACE ELEMENTS[2]

Element	as Compound	Parts per Million
Titanium	TiO_2	≤1
Zinc	ZnO	3200
Copper	CuO	470
Arsenic	As_2O_3	≤1
Selenium	SeO_2	≤1
Lead	PbO	≤1
Cadmium	CdO	≤1
Nickel	NiO	≤500
Chromium	CrO_3	80
Vanadium	V_2O_5	≤175

1. *Calculated from the sources below using the weighting given here and oil analyses given in Appendix C, assuming an average annual oil consumption of 4 percent on a Btu-input basis:*

Wood Type	*Source*	*Weighting*
Maple	*Babcock & Wilcox 1972*	.45
Maple	*Likens & Bormann 1970; McGirr 1979*	
Birch	*Fryling 1966*	
Beech	*Likens & Bormann 1970*	
White Pine	*McGirr 1979*	.2
Spruce bark	*Babcock & Wilcox 1972*	.35

2. *Trace element composition uses the sources listed above supplemented by analyses undertaken by the Environmental Measurements Laboratory at Dartmouth College for wood and bark of sugar maple, white birch, beech, white pine, fir and white spruce from southern Maine.*

filled, this leachate should pose no health hazard to drinking water supplies. However, the leachate may contain toxic substances including zinc, copper, nickel, chromium, and vanadium. These substances would pose a human health hazard if they were allowed to contaminate drinking water supplies. Should the leachate contaminate surface waters, these toxic substances may accumulate in living organisms (Dvorak et al. 1977).

Other possible impacts associated with ash disposal include transportation impacts (see Section 3.5.3) and blowing dust at the plant site or landfill. Sound management can minimize these problems.

Wood and oil ash components are based on analyses given in Appendix C.

3.2.7 Socioeconomic Characteristics

Operation of the proposed wood-fired power plant will require the thirty-two employees listed in Table 3.2.7-A. S.D. Warren currently employs thirty-five persons in the operation of the #17 and #18 oil boilers and the bark boiler, which will be shut down. Supplies used in the operation of the new boiler system will be similar to those currently used in the boiler area of the plant. Therefore, the plant will not increase local sales. The socioeconomic impact of wood procurement is discussed in Section 3.3.10.

With only a small decrease in employment and no net change in local purchases during operation, the operation of the proposed wood-fired power plant will not significantly alter regional income. There will be no change in indirect employment or income associated with the operation of this plant. Nonetheless, this facility will help to secure the contribution of the S.D. Warren Company to the local and regional economy by drastically reducing its dependence on increasingly scarce and expensive oil.

The plant will have a tax impact on the town of Westbrook. Assessed valuation of Westbrook in 1978 was $235,000,000 (MBT 1979). S.D. Warren currently has an assessed value of $66,521,120

TABLE 3.2.7-A: EMPLOYEES REQUIRED TO OPERATE PROPOSED PLANT

Job	Number of Employees
Control Room Operator	4
Assistant Control Room Operator	8
Woodyard Operator	4
Water Treatment Plant Operator	4
Maintenance Personnel	4
Scaleman	2
Clean-up	4
Mobile Equipment Operator	2
TOTAL	32

Source: Manar 1979d.

(Miller 1979). Present construction costs of the plant are estimated to be $56 million (Manar 1979a). Of this amount, $6.5 million is for pollution control equipment, which is exempt from property tax valuation. Current assessed value of the #17 boiler, #18 boiler, bark boiler, and bark handling equipment is $628,590. Thus, assessed value for the plant would increase by about $48.9 million. This increase would raise the assessed value of the town to $283,900,000. The 1978 assessed value of $235,000,000 at 90 percent valuation and a tax rate of $26 per 1000 produced approximately $5,499,000 in revenue. With an assessed value of $283,871,410, Westbrook could lower its local property tax rate to about $22 per 1000 (if all assumptions remained as stated).

However, this increase in assessed value could cause a decrease in state education funding which could preclude the potential reduction of Westbrook's tax rate. This plant would cause a 21 percent increase in the assessed value of the town. The state education funding to Westbrook could decrease if the total statewide assessment increased at a rate substantially less than 21 percent in the year that the plant was completed. This change cannot be accurately predicted. In 1978, the statewide increase in assessed value was 10.6 percent (Hickey 1979). If Westbrook's assessed valuation did increase by 21 percent, and the state's by only 10.6, Westbrook would see a decrease in state education funding.

The sale of electricity from the proposed wood-fired power plant will probably generate state and federal corporate income tax revenues. The amount generated, however, will depend on how the plant is financed, the final costs of producing the electricity, the agreed-upon selling price for the electricity, and other income that the power plant owner receives. Since many of these variables are uncertain at this time, it is impossible to predict the amount of corporate income tax that will be generated.

3.2.8 Archaeologic, Historic, Cultural, and Aesthetic Resources

Archaeologic

The site of the proposed wood-fired steam-electric station is of no archaeological value. Operations will have no impact on archaeologic resources (Shettleworth 1978a).

Historical

Operation of the proposed wood-fired facility will not impact historic resources: that is, structures within the Cumberland Mills Historic District or other historic areas of Greater Portland. The number of potential visitors to historic sites will not change (see Section 3.2.7). In addition, air emissions will not accelerate deterioration of historic structures, as operation of the proposed plant will reduce community airborne pollutant concentrations (see Section 3.2.1).

Cultural

Operation of the proposed biomass facility will not impact cultural resources of the surrounding community. The number of people demanding cultural services will remain the same (see Section 3.2.7), and changes in environmental pollutants will not reduce the appeal of cultural resources (see Sections 3.2.1-3.2.4).

Aesthetic

Operation of the proposed biomass facility will not deteriorate the aesthetic quality of the Westbrook area. Wastewater from the plant's operation will drain into the S.D. Warren treatment plant and will not degrade the aesthetic quality of the Presumpscot River (see Section 3.2.2).

The visual character of the area will be altered by the operation of the proposed plant. Two plumes, rather than one, will be visible to the community, as wood boiler emissions exit through a stack constructed for the new boiler and #20 oil boiler emissions exit through the old stack. Given equal atmospheric conditions, the new plume will be lower and denser than the current S.D. Warren plume. Visible plume volume will increase in the vicinity of the plant site and will decrease in more distant portions of Greater Portland.

Pollutant emissions should not be visible. At present, particulates only are slightly visible; particulate emissions will be

reduced through operation of the proposed boiler. The only constantly visible portion of the two plumes will be steam. Approximately one-third the current amount of steam will be emitted from the old S.D. Warren stack. A greater amount of steam will be emitted from the new stack due to the moisture content of the wood. Highest visibility will occur during cold periods when atmospheric conditions are stable and also when wood drying is in effect (see Appendix B).

The height of plume rise, a function of exit gas temperature and volume, must also be considered. The volume of gases from the existing stack will decline significantly when three of the four boilers exhausting through it are shut down. Therefore, its plume rise will be significantly lower given equal climatic conditions (see Appendix B). Due to both increased temperature and decreased volume, the plume rise from the proposed new stack will be less than that from the existing stack for any operating condition given an equal climatic situation (see Appendix B). Additionally, since the proposed stack will be fifty-three feet shorter, the emitted plume rise will originate at a lower elevation. Consequently, the area within which the plume is visible will be reduced.

Currently, every three and one-half hours for a period of fifteen minutes the S.D. Warren plume blackens as soot is blown out of four boilers' tubes. Two boilers are cleaned every three and one-half hours; each boiler is cleaned every seven hours (Hills 1979). The tubes of the wood boiler will not be blown when it is burning wood; the #20 boiler will remain on its present schedule (Cover 1979). Thus, three soot-blowing boilers will be replaced by one boiler that does not blow soot; the amount of soot released will be significantly reduced.

Noise Impacts

Operation of the proposed wood-fired facility will impact ambient noise levels in the surrounding community (see Table 3.2.8-A and Figure 3.2.8-A). Sound levels at S.D. Warren test stations southwest and west of the plant site, Stations 3 and 4, will increase. The levels at Stations 1,2,5, and 6 will remain

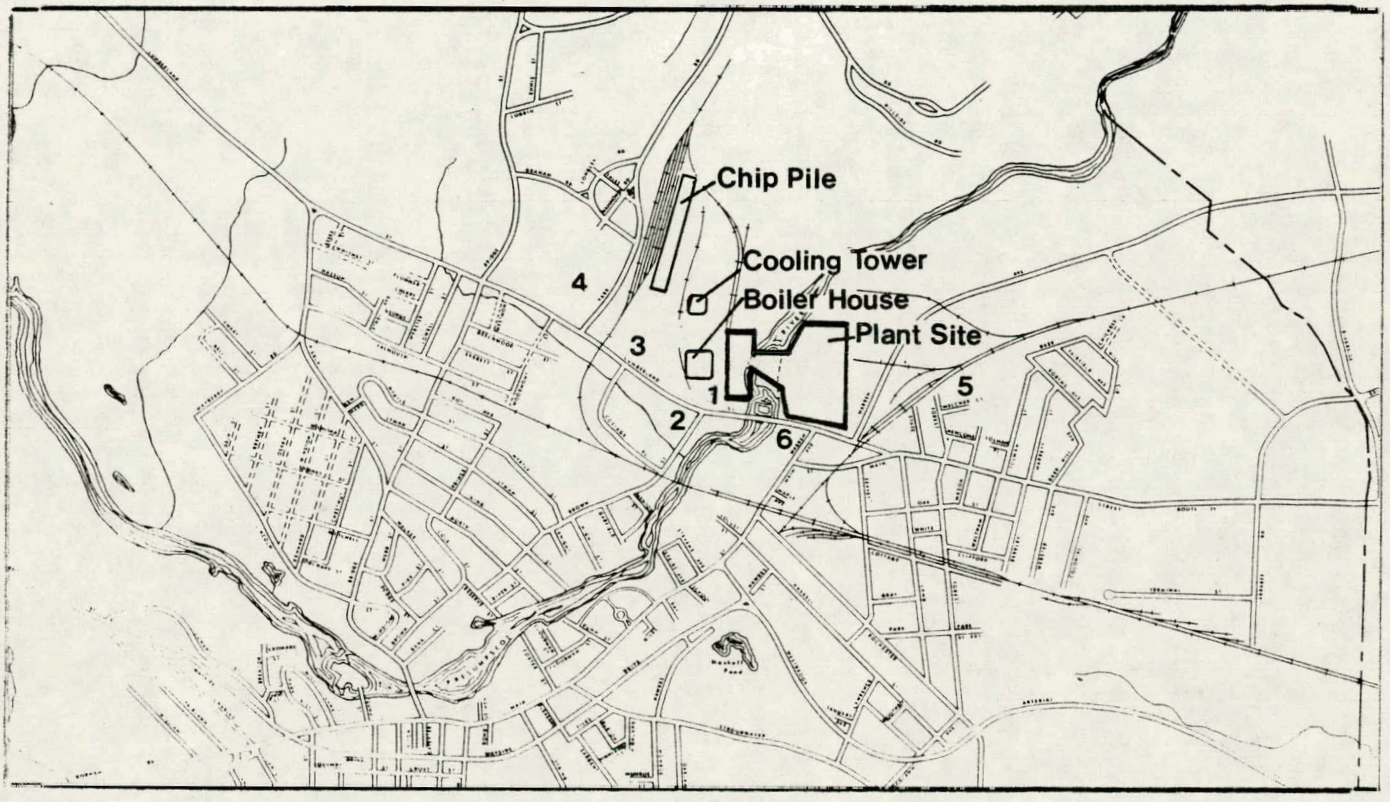
constant. Figure 3.2.8-A gives the location of these test stations.

The cooling tower and the chip pile bulldozer will contribute to operating noise (Griffin 1979c). Cooling tower sound levels will be low, however, and will not increase ambient noise in the surrounding community. The chip pile bulldozer, on the other hand, will increase average ambient noise levels at Stations 3 and 4 (Griffin 1979b). At Station 4, site of the Westbrook Community Hospital, which is situated in a residential area, the equivalent 24-hour sound level will rise by seven decibels to sixty-one decibels. This represents a total increase of about 120 percent. At Station 3, the equivalent 24-hour sound level will rise by four decibels to fifty-seven decibels, a total increase of 60 percent. The bulldozer will operate only about three hours each day (Finn 1979c), but during these three hours bulldozer and total sound levels will be high: sixty-nine decibels at Station 4 and sixty-three decibels at Station 3. These sound levels are not great enough to cause physiological damage or hearing loss, but normal outdoor speech communication will be hindered in the plant site vicinity (Bragdon 1970). As the bulldozer will not operate at night, sleep interference will not increase.

Although the table indicates an ambient noise increase at Station 5, this impact is unlikely to occur. Calculations assumed a free acoustical field, although the entire S.D. Warren industrial complex is located between Station 5 and the wood-fired facility. Therefore, noise impact will be minimal there.

The average day-night sound levels of Stations 3 and 4 currently stand at fifty-eight and sixty decibels, respectively. These levels exceed the outdoor day-night sound level (fifty-five decibels) which the U.S. Environmental Protection Agency has identified as requisite to protect the public in residential and hospital environments (EPA 1974). Operation of the wood-fired facility will raise the day-night sound level of Station 3 by two decibels to sixty decibels; the day-night sound level of Station 4 will increase by three decibels to sixty-three decibels. A three decibel increase is the minimum detectable by the human ear. Therefore, only at one of the six stations would the increase be marginally detectable. There would be no hearing loss hazard.

FIGURE 3.2.8-A: LOCATION OF THE SIX S.D. WARREN NOISE TEST STATIONS



KEY

Numbers show six ambient noise test stations. See Table 3.1.7-A for description of locations.

TABLE 3.2.8-A: AMBIENT NOISE LEVELS DURING OPERATION OF NEW FACILITY

(dBA)[1]

Test Station	Present S.D. Warren Sound Level[2]		NOISE ADDED: Cooling Tower Sound Level[5]		NOISE ADDED: Bulldozer Sound Level[5]		NOISE ADDED: Total		Total New S.D. Warren Sound Level		Increase Over Present Level	
	A[3]	A-P[4]	A	A-P	A	A-P	A	A-P	A	A-P	A	A-P
1. Cumberland St. & Gatehouse.	65	71	37	43	52	52	52	52	65	71	0	0
2. Cumberland St. & Brown St.	65	71	37	43	52	52	52	52	65	71	0	0
3. Cumberland St. & Cottage St.	53	58	36	42	54	54	54	54	57	60	4	2
4. Westbrook Community Hospital	54	60	33	39	60	60	60	60	61	63	7	3
5. Lower Forest St.--End	47	52	27	33	47	47	47	47	50	53	3	1
6. Cumberland St. & Warren Ave.	62	67	31	37	49	49	49	49	62	67	0	0

1. *dBA = decibels on A-weighted scale.*
2. *Source: Johnson 1974.*
3. *A = Annual average of $L_{eq}(24)$, or equivalent sound level over 24 hours.*
4. *A-P = Annual average of L_{dn}, or equivalent sound levels over 24 hours with 10-decibel penalty applied 10 p.m.-7 a.m.*
5. *Source: Griffin 1979b.*

Operation of the proposed wood-fired facility will not raise noise levels above that level which the city of Westbrook has identified as the maximum allowable level at the boundary line of an industrial zone. The 8-hour equivalent sound pressure level may not exceed seventy-five decibels, and any 1-hour equivalent level may not exceed one hundred decibels (Westbrook 1973). As the proposed plant will operate around the clock, the 24-hour equivalent level will always approximate the 1-hour and 8-hour equivalent levels. Based on Table 3.2.8-A, the highest 24-hour equivalent level during operation will be sixty-five decibels and will occur at Stations 1 and 2.

3.2.9 Pollution Incidents

The impacts of normal operation (described throughout Section 3.2) may be increased or substantially changed by rare catastrophic events that are difficult or impossible to predict and avoid. Such incidents may result from natural events (force majeure), failure of materials, or human errors in design or operation of the plant. Because of the unpredictability of these incidents, the extent of their impacts is difficult to assess.

Boiler or Turbine System Failure

The boiler and turbine system will be subject to control and inspection by the owners, the government, and insurance company engineers. Its operation will be monitored by safety equipment and supervised at all times by a resident engineer. In the unlikely event of a system failure, explosive release of steam, water, and burning fuel would pose a hazard to plant personnel. The release of these materials would not pose a serious threat to the environment or to the general public. No significant amounts of toxic substances would be released.

Pollution Control Equipment Failure

The full or partial failure of the air emission control equipment for particulates would result in a large increase in particulate emissions--in the worst case up to forty-two pounds per minute. The increased particulate emissions would probably

cause short-term violations of the ambient air quality standards and would affect people in the Westbrook area. The plant would be closed down if such a failure caused it to violate emissions standards.

Failure of the water cooling system could be detected quickly and would cause plant shutdown. Temporary discharge of heated water to the treatment facility and the Presumpscot River would be comparable in effect to the present heated water discharge at the S.D. Warren plant. Malfunction of the water treatment plant would have relatively little effect on the discharge from the power plant, as only the biological oxygen demand is controlled by that system. Total failure of the system would result in an increase in the biological oxygen demand of the waste discharge from four pounds to twenty-eight pounds per day.

Fire

Fire in the boiler plant or chip storage area or explosive fires caused by sawdust handling would pose a hazard to plant personnel but not to the general public. Fires would cause local air pollution problems but would not result in the release of significant quantities of toxic substances.

Floods

The plant, including the ash ponds, is above the level of those floods that are expected to recur every one hundred years. More severe floods, which are predicted to occur less frequently than once every one hundred years, could damage the plant. Flooding of the boiler facility could result in plant shutdown but would not have any significant environmental impact. Flooding of the ash ponds could release the ash and possibly contaminate the Presumpscot River, the soil, and ground water. The ash from the plant, along with the large quantities of other sediment and materials transported in such a large flood, would disturb both terrestrial and aquatic ecosystems. It is unlikely that this damage would be permanent, and the ecosystem would probably recover in time. The ash is low in toxic substances (see Section 3.2.6) and would not pose any threat to human health.

Earthquakes

The plant site is located in an area with a low probability of earthquakes (see Section 2.1.1). In the unlikely event of an earthquake of sufficient intensity to cause damage to the plant, the boiler or pollution control systems could fail. Damage to the ash ponds could cause leakage of ash and water to an extent similar to that which could result from floods.

3.3 IMPACTS OF HARVESTING

The impacts of harvesting for the proposed wood-fired power plant cannot be precisely determined. Wood for the facility will be procured from private logging contractors who, in turn, will purchase standing timber from private landowners. During the life of the project, wood will be harvested from a large number of locations throughout the fuelwood harvest region. Each of these locations will have site and vegetative characteristics that will determine its environmental susceptibility to different harvesting techniques. The landowners will have varying land management objectives that require different harvesting techniques and systems. Logging contractors will use different types and combinations of equipment as a result of their past experience, financial status, and the site to be harvested.

Despite these many variables, the impacts likely from varying types of harvest operations on sites with different characteristics can be assessed. The most important characteristic determining the environmental impacts of harvesting is the quality of harvest operation management.

3.3.1 Soils

Harvesting wood to fuel the proposed power plant will affect soils on the harvest sites and in some instances will change soil characteristics and increase soil loss. The severity of these impacts depends on harvesting practices and can be significantly reduced by good management.

The felling of trees alone does not lead to soil compaction or to appreciable soil loss (Patric 1977; Stone 1973); the preservation of leaf litter, humus, and the remaining root system, and the absence of physical disturbance to the soil, limit the impact on the soil's structural, chemical, and biotic characteristics. Lack of substantial change on the soil surface permits the maintenance of preharvest soil infiltration rates for precipitation and thus reduces the possible increases in surface

runoff. The removal of part or all of the tree canopy, however, does increase the amount of precipitation that reaches the forest floor and the velocity of rainfall hitting the surface. Rainfall may cause dislocation of the soil, particularly where the organic matter covering mineral soils has been mechanically disturbed or decomposed as a result of increased soil temperatures following harvest.

Rates of erosion on harvested sites will depend on the type of soil, slope, and the extent of the cut. The universal soil loss equation (see Appendix D) can be used to estimate soil erosion on a cut or uncut site. For undisturbed forests in the fuelwood region, erosion rates range from .004 to .020 tons per acre per year on 2 percent slopes one thousand feet long, to .26 to 1.23 tons per acre per year on 30 percent slopes. One ton per acre is approximately equivalent to a loss of .006 inches throughout an area. For clearcuts, erosion rates will range from .63 to 2.94 tons per acre per year on 2 percent slopes to 39.61 to 184.85 tons on 30 percent slopes (see Appendix D).

The erosion rate estimates of the universal soil loss equation do not account for erosion from prepared road surfaces and skid trails. Construction of the forest road network generally requires bulldozing the forest floor and commonly results in the removal of the organic matter in the soil. Where bulldozing is not necessary, the skidding of trees often removes the organic materials to as great a degree. The removal of organic matter in combination with compaction of the remaining mineral soils by vehicular traffic results in reduced soil infiltration capacity on the road and skid trail network. During heavy rainstorms, the rate of precipitation can exceed the infiltration capacity of the soil and cause surface runoff. Surface runoff (which does not normally occur in an undisturbed forest) can be further increased by the interception of subsurface groundwater flow by road cuts. The road and skid trail network may act as a conduit for the surface water and allow undisturbed flow over long pathways. Under these conditions, the erosive power of the runoff can become severe.

If roads and skid trails are improperly planned and maintained, soil losses to depths greater than one foot can occur. In situations where trails and roads cover approximately 15 percent of a harvest site, soil losses can be as much as 23.8 tons per acre in the year following harvest (MLURC 1978; Hornbeck 1978).

The harvesting impacts on soil are not irreversible. Revegetation and natural recovery of compacted soils follow the termination of an operation at a particular site. Thus, unlike agricultural lands where continuous cultivation leads to heavy soil loss on an annual basis, forested land is eroded only during cutting and for three or four years after cutting.

Soil erosion is management-dependent. The severe impacts of soil losses can be avoided by foresight. In general, clearcuts and strip cuts should be avoided on forested land with slopes greater than 15 percent. In addition, sites characterized by the most highly erosive soils in the fuelwood harvest region--the Belgrade, Hartland, Nicholville, Raynham, Salmon, and Winooski series--should not be harvested. These soils do not occur extensively in the region, however. Avoiding harvests on wet sites and during the spring snowmelt season will further reduce the incidence of soil erosion.

Severe erosion on trails, roads, and landings can also be prevented. Total road lengths can be reduced by as much as 40 percent if skid trails are properly planned prior to harvesting, rather than being laid out indiscriminately (Kochenderfer 1970). Losses in erosion from the prepared surfaces can be further reduced by countering the effects of concentrated runoff. This can be achieved by employing drainage and water dispersal techniques in the planning and construction of skid trails and haul roads and by using water bars, mulching, and planting grass after completion of the cut.

Although widespread high erosion rates of mechanically harvested sites in New Hampshire and Maine are not indicated by surveys of harvested sites (MLURC 1978; Verrier 1978), some erosion was found on most sites where preventive measures were not taken.

FIGURE 3.3.1-A: SEVERE EROSION
EFFECTS OF HARVESTING

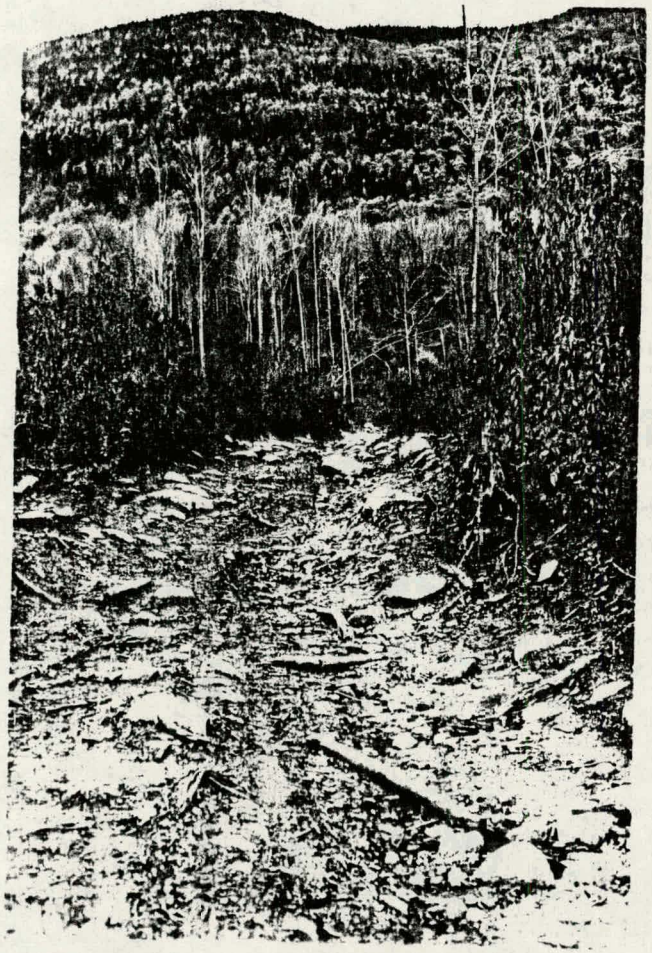
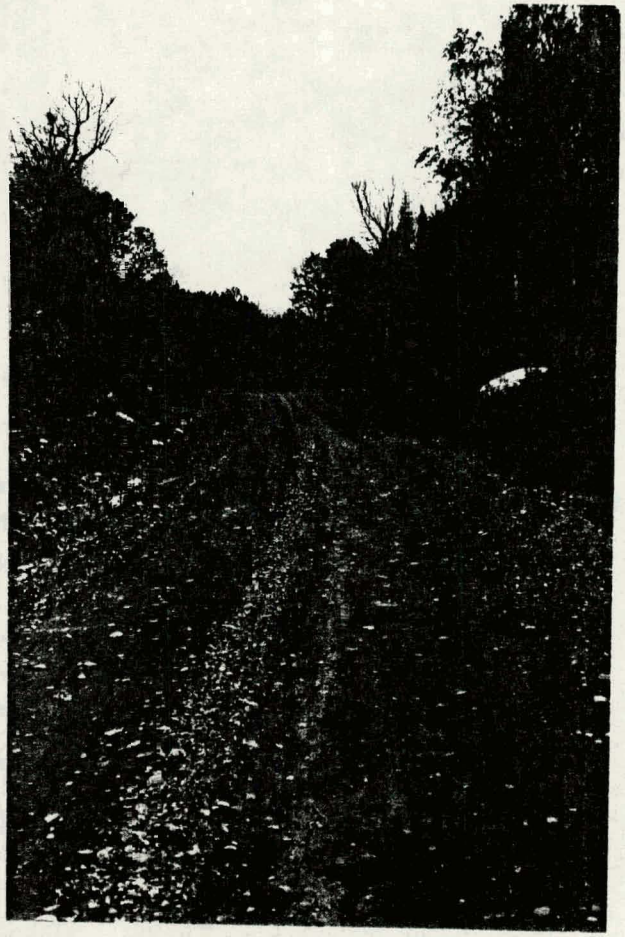


FIGURE 3.3.1-B: WELL-PREPARED
HARVEST TRUCK ROAD



One study in Maine found that on the great majority of sites, no erosion prevention methods at all were used (MLURC 1978).

3.3.2 Hydrologic and Water Quality Impacts

Fuelwood harvesting, on the scale required by this project, may change both the quantity and quality of water resources in the immediate vicinity of harvesting operations. The exact magnitude of such changes cannot be accurately calculated as they will vary with the hydrologic characteristics of a particular site, the type and configuration of the harvest, and the extent to which the contracted harvester implements water quality protection measures.

Water Quantity

As discussed in Section 2.1.3, trees intercept precipitation and transpire ground water. Thus, when trees are removed in a harvest, the 40 percent annual precipitaion which normally is evapotranspirated must be channelled through the remaining pathways, namely: ground water flow, overland flow, evaporation from the ground surface, or transpiration from the remaining plants. Increased ground water and overland flow will lead to greater volumes of water in receiving streams. In the first year following clearcutting, measurements at experimental forests in the Northeast showed increases in annual runoff of 20 percent (Lull & Reinhart 1967; Lynch et al. 1975). Changes on a strip cut in New Hampshire showed an increase of annual discharge of only approximately 5 percent (Hornbeck & Federer 1975). Other methods of cutting, such as diameter limit or thinning, cause smaller changes. Similarly, because of increased transpiration by surrounding undisturbed vegetation, fifty one-acre clearcuts will result in a lower increase in stream flow than one fifty-acre cut. Except for the clearcut, these changes in volume are no greater than those that would result from normal five-year variations in precipitation.

The increased streamflow following harvesting is not uniformly distributed throughout the year. Differences in the

streamflow between cut and undisturbed woods will be greatest when the loss of transpiration is most accentuated -- i.e., during the growing season. It was found that 92 percent of the annual increases during the first year after harvest in New Hampshire occurred during the growing season (Hornbeck, Pierce & Federer 1970). Fortunately, this coincides with the season of lowest streamflow; thus, even an extreme 344 percent increase in flow (as reported on a clearcut and herbicided watershed in New Hampshire by Hornbeck, Pierce & Federer 1970) will not create flooding problems.

Streamflows resulting from the spring freshet of snowmelt may be increased by a clearcut, because of reduced interception and subsequent evaporation of snow in the crowns of trees. However, the decreased tree cover will expose the accumulated snow pack to direct sunlight and evaporation, which will accelerate the melting process. Consequently, the snowmelt occurs four to eight days earlier on both clear and strip cuts than on surrounding uncut areas (Hornbeck, Pierce & Federer 1970). This desynchronization of melt results in a longer snowmelt period, but reduces maximum peak flows. Thus, less severe spring flooding may occur downstream from a cut.

Other hydrologic characteristics can be altered with cutting. Volumes of quick flow (following a storm event) and instantaneous peak flows were increased following harvesting on watersheds in the Northeast (Lynch et al. 1975; Bethlahmy 1972). In an extreme case, at Hubbard Brook, New Hampshire, a clearcut followed by herbicide application resulted in an annual quick flow volume increase of 37 percent, of which 74 percent occurred during the growing season. A change of this magnitude would not be expected following a normal harvesting operation. Also, the time between peak flow and base flow (recession) is increased, while the pre-peak time is decreased.

Hydrologic changes are most pronounced during the first grow ing season following harvesting. With each year after that, revegetation of cut areas increases transpiration and decreases streamflow. With partial cutting, increases in streamflow dis-

appear after two years. Significant changes in runoff from clear cuts remain for five to six years following harvesting.

Water Temperature

Water temperature will change when the canopy cover overhanging a stream is removed. The canopy shades the water from direct solar radiation. On watersheds where streamside trees were cut, maximum mean daily temperatures during the summer often showed increases of 10°F over adjacent, uncut watersheds (see Corbett, Lynch & Sopper 1978; Kochenderfer & Aubertin 1975). Fluctuations depended on the volume of the stream and aspect of the stream's exposure. Small headwater streams are more susceptible to increased temperature stress, since a given solar heat input will raise temperatures at a rate inversely proportional to the volume of water.

Maximum temperatures in unshaded upland streams may be expected to rise above 75°F (Corbett, Lynch & Sopper 1978). Minimum summer temperatures are unaffected by cutting, although winter minimums may be three to four degrees cooler in the exposed stream (Lee & Samuel 1976). With normal revegetation of the stream bank the temperature effect will disappear after four to five years.

Increased temperature stress on streams may be avoided entirely if streamside vegetation is left uncut during harvesting. Maximum protection is provided by a buffer strip eighty feet wide, while fifty-five feet would provide 90 percent protection (Lynch, Corbett & Hutnik 1975). State law requires partial buffer strips in both Maine and New Hampshire.

Water Quality

Dissolved solids. As discussed in Section 3.3.3, the removal of the tree canopy may lead to accelerated nutrient loss from a site. This excess nutrient loss ultimately reaches surface watersm draining a site. Possible water contamination by these nutrients is of concern.

Nitrate has been found to be the nutrient most likely to be leached in high quantities into streams. Because nitrates can possibly cause infantile neurological disorders, nitrate concentrations (measured as nitrogen) in drinking water must be kept

below 10 milligrams per liter (mg/l) (CFR 1977). Specific standards for surface waters have not been set. In undisturbed forests in the White Mountains, average concentrations of nitrate range from 0.11 to 1.1 mg/l (Hornbeck et al. 1975). After an extreme experiment at the Hubbard Brook site, in which all trees were cut and herbicide applied for the following three growing seasons, streamwater nitrate concentrations rose from a precut maximum of .45 mg/l to a maximum of 20 mg/l (Pierce et al. 1972).

Harvests for this project should not cause such extreme changes, however. Subsequent studies at Hubbard Brook showed that strip cutting increased mean nitrate concentrations by 1.23 mg/l during the first year and reached a maximum of 1.32 mg/l greater than precut levels in the second dormant season following the cut. After block cutting, the nitrate concentrations reached a maximum of 5 mg/l in the year following the cut (Kochenderfer & Auberton 1975). Studies of streamwater at seven clearcuts in the White Mountains showed average nitrate levels to range from 1.3 to 4.2 mg/l, with a maximum of 6.2 mg/l.

Other nutrients will also respond to cutting, as discussed in Section 3.3.3; however, the magnitudes of change are less than for nitrate. Public health limitations recommend that drinking waters not contain greater than 250 mg/l of chlorides and sulfates or 500 mg/l of dissolved solids (USPHS 1962). In addition, Maine state law requires that streams tributary to ponds not contain greater than 50 parts per billion of phosphorous per liter. Extreme phosphorous concentrations on the clearcut and herbicided Hubbard Brook watershed reached only 2.6 parts per billion (Hobbie & Likens 1973).

Sulfate concentrations in waters after harvesting have been consistently lower than those in undisturbed watersheds, and do not, therefore, pose a water quality problem (Hornbeck et al. 1975; Corbett, Lynch & Sopper 1978). Calcium, magnesium, potassium, and sodium all show minor increases in streamwater concentrations following clearcuts.

The effects of harvesting on nutrient loading of water reaches a maximum during the second year after a cut. After this, revegetation actively consumes those nutrients that would have previously left the system. Similarly, decomposition of organic matter is slowed down as revegetation occurs. Increases in nutrient concentrations will depend on the percentage of a drainage basin cut.

Waters draining from uncut sectors of a basin will dilute the increased nutrient concentrations. This mixing effect will be roughly equivalent to the proportions of a basin which are cut versus uncut (Pierce et al. 1972). Thus, waters further downstream from a harvest show less noticeable increases in nutrient concentrations.

Suspended solids. The most significant water quality problem associated with tree harvesting is sediment production. Undisturbed forest streams in the east generally have less than 5 mg/l of suspended solids in their waters during nonstorm periods (Lynch, Corbett & Hutnik 1975). During heavy storms, maximum concentrations of 11 mg/l of suspended solids have been reported (Lynch et al. 1975). Aquatic ecosystems are considered to be afforded high levels of protection when suspended solids do not rise above 25 mg/l (EPA 1973).

Clearcuts within the northeast region, conducted with restrictions on skidding practices, showed a maximum of 550 mg/l (Lynch et al. 1975). These levels will occur during major storm events when erosive energies are at a maximum. During nonstorm periods, sediment loads will increase only negligibly, and may, in fact, be no different from those expected in uncut watersheds (see Aubertin & Patric 1974).

For drinking water, the suspended sediment content measured in Jackson Turbidity Units (JTU) generally should not exceed 1 JTU and in no circumstances should it exceed 5 JTU (CFR 1977). Although the suspended sediment yields (in mg/l) referred to above cannot be directly translated into turbidity units, experience has shown that streams draining logging operations may be far in excess of federal drinking water standards. Turbidities

ranging from 5,200 JTU to 56,000 JTU are reported from harvest operations in the Appalachians (Kochenderfer & Auberin 1975). Experimental stripcuts in New Hampshire produced turbidity levels of 38 JTU (Hornbeck & Federer 1975). Streams of undisturbed watersheds reported from Hubbard Brook, New Hampshire, are usually below 1 JTU.

Problems of sedimention from forestry operations can be almost eliminated by the implementation of several well-understood erosion control techniques. Outsloping, culverts, and water bars all allow water to drain from skid trails and other prepared surfaces, thereby avoiding the greatest sources of sediment from a cut. Similarly, the retention of uncut buffer strips along streams will allow overland flow to seep into subsurface flow; transported soil particles will thereby be settled onto the ground surface rather than into the streams.

As with other hydrologic effects, turbidity increases are of temporary duration. Fifty to 80 percent of all erosion-induced sediment loading occurs during the first year following cutting (EPA 1975). At a 21-acre clearcut in Pennsylvania, suspended sediment concentrations during storm periods decreased from an average of 196 mg/l during cutting to 11 mg/l during the following year, and varied between 3 and 13 mg/l during the following four years (Lynch, Corbett & Hutnick 1975). Nonstorm turbidity measurements during the four years after cutting averaged 2.0 mg/l, with a maximum of 17.1 mg/l (Lynch, Sopper & Partridge 1972).

3.3.3 Nutrient Cycles

Forest harvest operations will affect the process of nutrient cycling in the forest ecosystem. Because available nutrients support the production of forest biomass, there is concern over the potential of intensive fuelwood harvesting to disturb nutrient cycles. Primary consideration is given here to the harvest systems that have the greatest potential for impact although other less-intensive systems are also discussed.

Nutrient Input Mechanisms

Each forest ecosystem is an interrelated component of a larger, ultimately global system, with inputs of nutrients from sources extraneous to the internally cycling system. These sources, which are extensively discussed in Appendix D, include precipitation, aerosol impaction, weathering of the geologic substrate, and gaseous fixation. Harvest impacts on these mechanisms are discussed below.

Precipitation. The temporary absence of vegetation on a harvested site will not significantly affect the amount of nutrients brought into the system by precipitation, although the manner in which these nutrients actually enter local cycles may be altered (Likens et al. 1977). The amount of precipitation intercepted by the forest canopy will vary depending on the extent of the harvest. This change may alter the subsequent pathways of the precipitation nutrient inputs through the ecosystem as described below.

Aerosol impaction. Some nutrients suspended in the air are deposited on leaf and stem surfaces and later washed to the forest floor by rainfall. The impact of harvesting on "aerosol impaction" is directly related to the quantity of leaf and stem surface area removed and is not directly related to the harvest technology. In some forested ecosystems, disruption of the aerosol impaction process may reduce the primary input source of many of the critical nutrients (Art et al. 1974). In the northern hardwood forest, changes in aerosol impaction may affect the ecosystem's sulfur cycle (Likens et al. 1977). However, the severity of the impact would be mitigated as vegetation reclaimed the site (see Section 3.3.4).

Weathering. The impacts of harvest operations on the rate of chemical weathering of bedrock are difficult to assess. The removal of substantial quantities of vegetation reduces the buffering effect of the forest canopy on precipitation and this increases the acidity of rainfall entering the soil (Eaton, Likens & Bormann 1973). The additional hydrogen ions added to the soil water solution could accelerate the rate of chemical wea-

thering in the system. Likens et al. (1977) found that acidity resulting from biological processes, primarily decomposition, also plays an important role in the weathering process. There is evidence that intensive harvest operations initially accelerate decomposition (Likens et al. 1970) and the weathering rate (Likens et al. 1978).

The net effect of these processes on soil water acidity and the subsequent rate of nutrient inputs from chemical weathering is unclear at present. If there were a significant increase in weathering, however, an increase in the rate of leaching output would probably occur until the regenerating vegetation resumed uptake of the surplus nutrients.

Gaseous fixation. Nitrogen and sulfur fixation processes can be affected by harvest practices. Small woody litter supplies the only major substrate for nitrogen-fixing bacteria (Roskoski 1977). The amount of this material remaining after whole-tree harvests would be substantially less than that abandoned during conventional harvests. Since gaseous fixation constitutes one of the major nitrogen inputs (Likens et al. 1977), this characteristic of whole-tree harvesting could pose a constraint to the recovery of the post-harvest ecosystem.

Vegetation is capable of using sulfur dioxide directly from the atmosphere (Likens et al. 1977). The impact of harvesting on this mechanism, therefore, is directly proportional to the reduction of living foliar surfaces and is not dependent on the technology employed in the harvest. Since the dominant input of sulfur to the ecosystem is delivered in precipitation (Likens et al. 1977), the impact of harvests on the input of sulfur should be moderate and, in any case, limited to the period of initial revegetation.

Internal Cycling Mechanisms

The mechanisms by which an ecosystem transfers nutrients among its various components can be affected by harvest operations. In some cases these processes may be very efficient and permit net gains to the system over time; in other cases, net losses may occur. To the extent that harvests disrupt the inter-

nal nutrient flux, the stability of the ecosystem may be impaired. The importance of these internal mechanisms can be illustrated by comparison with the input processes and vegetation uptake. As presented in Table 3.3.3-A, the quantities of nutrients cycled between the aboveground biomass and the forest floor are substantially larger for several of the major nutrients than the geologic and meteorologic inputs to the ecosystem (Likens et al. 1977).

Leaf wash and stemflow. As precipitation enters the forest ecosystem, it is partially intercepted by the canopy vegetation (see Appendix D). Material is leached and washed from the leaves and stems and is returned to the forest floor (Likens et al. 1977). The acidity of water reaching the soil can be substantially buffered by this process (Eaton, Likens & Bormann 1973). Removal of these interception surfaces diminishes the amount of nutrients carried to the forest floor and may also increase the acidity of the soil. The significance of this change is unclear, although the increases in acidity could affect the leaching of nutrients from the soil. The effects of removing these nutrients from the forest floor are discussed under "Nutrient Output Mechanisms."

Uptake and storage. A vital role in the conservation of nutrients within an ecosystem is played by the forest vegetation and microorganisms. Many of the nutrients extracted from the soil and atmosphere to support metabolic processes are subsequently incorporated into the physical structure of the forest organisms (Likens et al. 1977). This storage serves as a buffer against large depletions of the system's nutrient "capital." Disruption of this uptake and storage mechanism during harvesting leaves the site open to a variety of physical and biological forces that may deplete the stock of available nutrients. The importance of this impact is defined by the quantity of vegetation removed in harvesting and the length of the subsequent regeneration period.

Decomposition and mineralization. The decomposition mechanisms in the forest ecosystem transform dead biomass (litterfall) and its constituent nutrients into a variety of organic and

TABLE 3.3.3-A: COMPARISON OF NUTRIENT INPUTS AND SELECTED INTERNAL FLUXES

	NUTRIENTS (*kilograms/hectare/year*)					
INPUT MECHANISMS	Calcium	Potassium	Nitrogen	Sulfur	Magnesium	Phosphorus
Precipitation, weathering, gaseous fixation, or aerosol impaction	23.3	8.0	20.7	19.6	4.1	0.04[2]
INTERNAL CYCLING MECHANISMS						
Litterfall, root litter, throughfall, stemflow, and root exudates	54.1	58.5	70.6	29.3	8.6	6.6
Vegetation uptake	62.2	64.3	79.6[1]	24.5[1]	9.3	8.9

1. *Root uptake only.*
2. *Rate of weathering is unknown.*

Source: Likens et al. 1977.

inorganic forms. As described in Appendix D, these forms either become available for further plant uptake and leaching processes, or remain bound in organic soil components unavailable to either of these processes. Harvest operations can increase the rate of soil decomposition by increasing the light and moisture that reach the forest floor (Bormann et al. 1974). This in turn causes increased mineralization of nutrients, which can then be leached from the system (Likens et al. 1978). The resulting decrease in the organic content of the soil will alter physical properties of the soil such as bulk density and moisture-holding capacity (Smith 1962), which may affect future regeneration. Whole-tree removal eliminates slash which may shade the forest floor and consequently accelerate decomposition more abruptly than traditional harvest systems.

Nutrient Output Mechanisms

The processes by which nutrients are removed from the forest ecosystem clearly represent a critical area for the effects of harvesting. While undisturbed northern hardwood forest ecosystems can actually experience annual net gains in certain nutrients (Likens et al. 1977), harvesting directly removes nutrients from the forest and also affects the normal output mechanisms.

Biomass removal. Extensive research efforts have been conducted to determine the quantities of nutrients removed by different harvest systems. The results of these are extensively discussed in Appendix D and will only be summarized here. Comparison has been made between conventional (bole-length) and whole-tree (aboveground) clearcutting techniques. Whole-tree harvests generally remove between two and four times the quantity of nutrients removed by conventional harvests (Weetman & Webber 1972; White 1974; Boyle, Phillips & Ek 1973; Jorgensen, Wells & Metz 1975; Hornbeck 1977). Not only is a significant nutrient storage pool eliminated because of this removal, but internal fluxes -- such as litterfall, throughfall and stemflow -- which return nutrients from biomass "storage" to the soil system are disrupted.

The removal of all aboveground biomass in a whole-tree harvest would halt the flow of stored nutrients to the soil layer with an inevitable impact on the nutrient reservoir available to the regenerating stand. The significant difference between conventional and whole-tree harvests occurs because the nutrients stored in biomass are disproportionately concentrated in the leaves, limbs, and twigs, which are left behind in conventional harvest (Likens & Bormann 1970; Whittaker et al. 1974). This slowly decomposing material (slash) serves to cushion the effect of the increased, leached nutrient losses that have been observed after harvest operations (Hornbeck 1977).

Slash also serves several additional functions. Decomposing slash maintains the organic content of the soil, which in turn increases moisture-holding capacity and sustains microbial activity (Smith 1962). Slash can provide protection from erosion processes by reducing the impact of precipitation. By providing some shelter from the increases in temperature at the forest floor which normally follow intensive harvest operations, slash may ameliorate the effects of increased soil decomposition. This action may reduce the availability of nutrients for leaching when there is little vegetative uptake occurring. Slash may also provide some shelter from climatic extremes for regenerating vegetation. The role of slash in a forest ecosystem is further discussed in Section 5.7.1.

Leaching. The principal mechanism removing nutrients from a undisturbed forest ecosystem is the leaching effect of precipitation (Likens et al. 1977). Precipitation leaches nutrients from leaves, tree stems, litter, and the soil. Depending on the ability of the soil to hold nutrients in either organic or inorganic forms and the ability of the existing vegetation to take up nutrients, precipitation will carry nutrients, in solution, out of the system. The extent of this process is also affected by the acidity of the system and the amount of precipitation (Likens & Bormann 1970; Likens et al. 1970; Eaton, Likens & Bormann 1973).

Harvesting affects the leaching process by:

- increasing the decomposition rates in the forest floor,
- removing the uptake and storage sink provided by growing vegetation,
- increasing the quantity of precipitation reaching the forest floor, and
- increasing the acidity of the soil regime.

As mentioned earlier, progressively heavier harvests increase the amount of light and moisture reaching the forest floor. These increases, coupled with a concommitant rise in temperature, accelerate the rate of decomposition and mineralization in the forest floor. Nutrients bound in the organic soil material are thus released and dissolved into the soil solution. With the amount of vegetative nutrient uptake reduced by the harvest, these nutrient solutions drain from the system. This tendency is enhanced in the harvest region by the low ability of the acidic soils to hold inorganic nutrients (see Appendix D). Accelerated decomposition exacerbates this situation by reducing the soil's organic components, which could hold inorganic nutrients with ionic bonds (referred to as cation exchange capacity).

Acidic precipitation, which has become typical of the Northeast, could incrementally reduce long-term productivity through increased nutrient leaching or by interference with biological processes (Likens et al. 1977). If this is true, intensive harvest practices may have a synergistic effect. The northern hardwood forest canopy buffers acid rain, in some cases increasing the pH by almost a full unit (Eaton, Likens & Bormann 1973). Complete removal of the forest canopy could increase the acidity of precipitation reaching the forest floor and in turn increase the quantity of nutrients lost through leaching.

Volatilization. Certain decompositional processes can volatilize specific nutrients, including nitrogen and sulfur (Brady 1974). This volatilization occurs under anaerobic conditions and is thought to constitute a relatively minor output pathway, although certain conditions can induce higher rates of output (Wilde 1958). In general, the impact of harvesting on this mechanism is related to its effect on the soil moisture regime.

In low-lying, poorly drained areas, vegetative cover may play a crucial role in maintaining aerobic soil conditions, via the process of evapotranspiration. Intensive harvest operations, either conventional or whole-tree, could affect an increase in soil moisture and create anaerobic conditions favorable to volatilization. Limiting the intensity of harvest in low-lying areas would control the significance of this impact.

Erosion. Erosional processes are capable of carrying, in suspension, particulate matter with nutrients out of the system. Although soil loss rates from undisturbed forest stands are very low, harvest operations can increase the rate of erosion (see Section 3.3.2). In general, whole-tree and conventional harvest operations have similar erosion impacts. It is possible that whole-tree harvests could accelerate soil loss by removing the protective ground cover provided by logging slash.

Summary and Conclusion

From this discussion, it is clear that fuelwood harvest operations, particularly whole-tree harvests, can affect the function of the nutrient cycles in forested ecosystems. Input, output, and internal cycling mechanisms are affected to varying degrees. As a result, the pools of nutrients available to support forest growth can also be affected, both in the short and long term.

The severity of these impacts, however, is critically dependent on several variables. The extent of removals undertaken during any type of harvest operation will affect the intensity of impacts on cycling mechanisms and reserves of available nutrients. In addition, the skill with which a harvest is planned and executed will affect the severity of the potential impacts, including erosion. The degree to which regeneration of the site is affected appears to have a major influence on most of the cycling mechanisms. To the extent that regeneration is delayed, the disruptive effects of harvests are likely to be prolonged, especially in the case of clearcutting operations.

The severity of impacts on nutrients also depends on those soil characteristics that affect nutrient cycles. The wide varia-

tion in soil types within the harvest region indicates that the degree of impact from any type of operation will vary from site to site.

Lack of knowledge about the complex cycling processes and mechanisms increases the difficulty of assessing the severity of harvest impacts. Intensive monitoring of the nutrient cycles and harvest practices in the procurement region is necessary and constitutes one of the principal justifications for this demonstration project. The questions answered by this research will permit a more accurate assessment of the advantages and drawbacks of using wood energy.

3.3.4 Terrestrial Ecosystems

Harvesting fuelwood for the proposed wood-fired power plant will affect the terrestrial ecosystems of the harvest region, described in Section 2.2.5, primarily through the removal of vegetation. To a lesser extent, the ancillary activities associated with harvesting, including road building, will also affect the character of these ecosystems. Harvesting results in gross structural ecosystem changes and affects the environmental suitability for flora and fauna, in addition to changing the flow of nutrients, as described in Section 3.3.3. The possible extent of these changes is dependent on the intensity of harvest operations (see Section 3.3.7).

Flora

Forest regeneration and succession. Harvesting alters forest succession, the process by which forest communities develop and replace each other (see Section 2.2.5). Many of the variables that affect this change are dependent on choices made by forest landowners and the harvest practices employed by loggers.

Natural regeneration typically occurs promptly following traditional harvest operations in the northeast and is relied on by most foresters and landowners. The intensity of harvest operations determines the environmental parameters which, in turn, affect the regeneration opportunities for the new members of the forest com-

munity. The amount of light and available moisture and the temperature of the soil following harvest depend upon harvest intensity. While selection cutting may only slightly alter the conditions of the existing stand, seed-tree or clearcutting methods will substantially alter the growing conditions for the new stand. Variations in these critical parameters determine microclimates to which the various tree species are adapted.

Harvesting can also affect the structure and exposure of the soil itself (Smith 1962). The changes in light, temperature, and moisture can affect the rates of bacterial and fungal decomposition in the upper soil horizons and can result in significant decreases in organic content of the soil (Likens et al. 1970). This change further affects the moisture regime of the seed bed and limits initial regeneration to species adapted to low moisture availability and to temperature extremes.

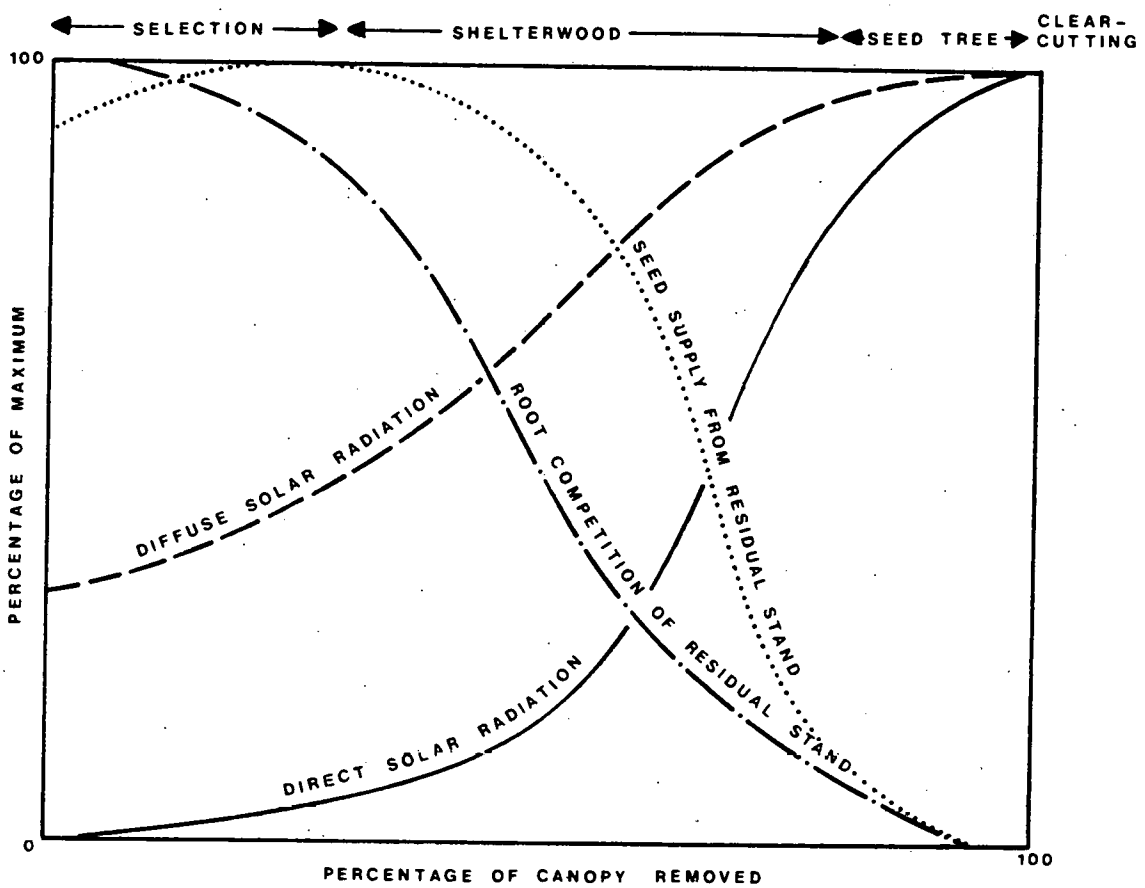
Natural sources of seed are also changed by harvest practices. The relatively small removals associated with selection cuttings leave behind many potential seed trees, which support regeneration of a stand similar to the original. Increased removals diminish readily available seed sources and favor species on adjacent sites with light, easily dispersed seed.

Finally, the equipment used in harvesting can disturb the forest floor, exposing mineral soil as a seed bed. Some species require this condition for regeneration, and hence are favored over species that prefer undisturbed, organic forest litter as a seed bed.

As the removal of vegetation from a stand increases, the early successional or pioneer species are increasingly favored (see Section 2.2.5). This tendency is inherently neither beneficial nor detrimental to the terrestrial ecosystems of the area. The effects of harvest operations can, to some extent, be viewed as analogous to natural disruptions including windthrow, disease outbreaks, and fire.

In addition to microclimatic changes caused by harvesting, a variety of site-specific variables can also influence the composition of the regenerating stand. For example, most sites will have

FIGURE 3.3.4-A: THE EFFECTS OF INITIAL CUTTINGS ON VARIOUS METHODS OF REPRODUCTION



Note: Root competition is for both moisture and nutrients. Seed bed temperature is directly proportional to direct solar radiation.

Source: Smith 1962.

some amount of advanced regeneration under the stand to be harvested. These young trees can substantially influence the make-up of the new stand if they are not destroyed during harvest operations. While intensive harvests conducted during summer months will typically inflict substantial damage to advanced regeneration, the snow cover of the winter season can provide protection. In many cases the availability of advanced regeneration is a critical determinant in the rapid regeneration of the site (Smith 1962). This is particularly true in the case of sites that are difficult to regenerate from seed, due, for example, to extreme variation of the temperature of the seed bed or to moisture deficiencies. Other factors, including soil type, exposure, and browsing pressure will influence the composition of the regenerating stand.

As discussed previously, past harvest practices have generally been "high grading" operations, which leave behind only the poor quality trees to become the parent stock of the new stand (Ferguson & Kingsley 1972). The lack of conscious planning in the proposed fuelwood harvest region for the composition of the the regenerating stand appears to have generally encouraged a haphazard mix of early and mid-successional communities. These stands typically include aspen, pin cherry, white pine and gray birch. Other species may also be found, depending on the characteristics of the specific site.

The fuelwood market will create a demand for many species and allow the utilization of low-grade material that was not previously merchantable. The relatively low value of this material favors the use of the most efficient harvest methods (see Section 3.3.7). From the loggers' point of view, the use of mechanized whole-tree equipment in intensive harvests provides the greatest return. Sites that can be made available to this harvest system are likely to bc utilized before sites with more stringent harvesting constraints, such as would be encountered in selective cutting and thinning operations. This will result in conditions generally more favorable for the regeneration of early successional, even-aged communities in the fuelwood harvest region.

Other, higher value forest products, including pulpwood and sawtimber are also drawn from the fuelwood harvest region. Whole-tree harvesting allows landowners to thin, selectively harvest or weed low-grade material from their stands to favor existing, higher quality trees. In this case, the proposed action may contribute to the maintenance of later successional communities.

Except in shoreland areas or other special use areas where state laws regulate harvest intensity, the principal determinant of the type of successional communities resulting from fuelwood harvest for this project will be the policies adopted by the individual landowners in the fuelwood harvest region. While these choices can be influenced by regulatory mechanisms and landowner education and assistance programs, the existing situation allows the landowner a wide latitude in his harvest decisions.

Long-term forest productivity. The effects of mechanized, whole-tree harvesting on the long-term productivity of the forest resource is an issue of current concern. This harvest system removes a greater percentage of the ecosystem's available nutrients than do the conventional "stem" or "bole" harvest systems (Weetman & Webber 1972; White 1974; Boyle, Phillips & Ek 1973; Hornbeck 1977; Jorgensen, Wells & Metz 1975). In addition, the criteria for acceptable fuelwood are substantially less stringent than those for other forest products, especially in terms of size and quality. This difference could result in shortened harvest rotations. If a combination of these factors were to result in a net depletion of available nutrients over the long term, productivity would be reduced (Aber, Botkin & Melillo 1978). As described in Section 3.3.3, current research indicates a large degree of uncertainty about the actual effect of wholetree harvesting on long-term availability of nutrients.

Rare and endangered species. Only one plant in Maine, the Furbish lousewort, has been federally designated as an endangered species (USFWS 1978). Several other plant species have been proposed for this listing, and a wide variety of additional species are recognized by botanists to be rare or unusual in Maine (see Appendix D). The Furbish lousewort occurs along wooded river or

stream banks and in low, shaded swampy areas. To date, the lousewort has been found only along the banks of the St. John River. Research indicates that the range of the lousewort is restricted in this area (Nickerson 1979). Harvest operations in the proposed fuelwood region would not affect this plant.

Of the species proposed for endangered listing, only one, the small whorled pogonia, could be affected by harvests in the fuelwood region. This orchid grows in dry or moist leaf mould under mixed hardwood forests (Eastman 1977). The small whorled pogonia is very sparsely distributed throughout the North Atlantic states east of the Mississippi River, with the majority of sites occurring in the New York-New England area (Eastman 1977: see Appendix D). Of the two known sites in the fuelwood harvest region, one in North Sebago, Maine, has been proposed for inclusion in the Maine Register of Critical Areas.

If the small whorled pogonia is listed as an endangered species by the U.S. Fish and Wildlife Service, the Department of Energy will undertake the necessary planning and management efforts to assure the protection of this species. The ongoing research conducted by the U.S. Fish and Wildlife Service in cooperation with the state of Maine would provide the information needed for such an effort (Dyer 1979). The remaining plant species proposed for listing are either not found in the area of the proposed action or are found in habitats which would not be subject to harvesting, such as alpine gardens and marine estuaries (Dyer 1979).

Fauna

Upland and wetland species. Fuelwood harvesting, particularly mechanized whole-tree operations, will increase the amount of "edge" habitat in the harvest region. These operations could also increase the areal extent of early successional forest communities. Both changes would have several effects on animal populations in the harvest region. If the amount of edge habitat were increased and a diversity of forest types and ages were maintained, then an increase in the diversity of species would be

expected (Webb 1973). The creation of additional early successional habitat would favor many species with economic value to Maine and New Hampshire. These species include white-tail deer, ruffed grouse, snowshoe hare, moose, and others.

Nongame species, including many songbirds, can also benefit from these habitat types. Each of these game and nongame species, however, also depends on other types of vegetation associations. An example of this is the need for dense stands of conifers, typically hemlock, spruce, and fir, to provide wintering areas for white-tail deer. Harvest of these stands can have detrimental effects on local deer populations. In general, those species which in whole or in part depend on late successional vegetation could be negatively affected by harvesting for the proposed plant.

Over time, the harvest activity can be expected to expand the existing network of logging roads and, as a result, increase access to many of the currently remote portions of the harvest regions. Increased hunting and recreational pressures engendered by this access may have detrimental effects on some species of wildlife, including deer. The extent of these impacts are difficult to determine, due to the control individual landowners can exercise over access.

As discussed earlier, the diversity of ownership objectives likely to exist in the fuelwood harvest region and the economic constraints of harvest operations make an accurate prediction of the impacts on specific wildlife species difficult. A large number of decisions will be made by individuals not involved in the proposed action. For the most part, these decisions and related actions are beyond the control of the Department of Energy and its cooperators. Although some restrictions can be exercised over the impacts of harvest operation through wood procurement contracts and existing state forest practices regulations, the enforcement of these measures will be difficult.

Rare and endangered species. The bald eagle and short-nosed sturgeon are the only species of fauna known to exist in Maine that have been designated as endangered under the Endangered

Species Act of 1973 (USFWS 1978; Gramlich 1979; Squiers 1979a). Harvest operations can affect bald eagles in several ways. Removal of trees suitable for nesting and roosting limit eagle populations. Harvests and other management activities can also affect eagles indirectly by reducing fish populations or introducing persistent chemicals into the food chain. These detrimental activities are controlled to some extent under state laws, but compliance is largely dependent on decisions made by individual landowners and harvest operators.

Direct interference with bald eagles is prohibited under the Endangered Species Act of 1973, as amended, and the Bald Eagle Act of 1940. A successful identification and protection program is now underway, conducted by the U.S. Fish and Wildlife Service in cooperation with the state of Maine. The location and habits of the few eagles that nest on the periphery of the fuelwood harvest region have been well documented and protected by this program (Gramlich 1979). Harvest activity associated with the proposed action will not jeopardize these populations.

The impacts of harvesting on the short-nosed sturgeon are discussed in Section 3.3.5.

The historical distribution of the eastern cougar, grey wolf, Indiana bat, all listed as endangered, extends into the fuelwood harvest region (USFWS 1978). Current populations in this region, however, are nil and the species are not scheduled for reintroduction efforts at this time (Nickerson 1979). The peregrine falcon, also an endangered species, may migrate through the harvest region but does not use the region for nesting and breeding (Nickerson 1979). Harvest activities will not affect populations of this species (Nickerson 1979).

Use of Pesticides

Although the influence of fuelwood harvesting on the use of herbicides and insecticides is presently unclear, several possible changes in the current patterns of pesticide use would have impacts on populations of flora and fauna.

Fuelwood harvests may, in some instances, constitute an alternative silvicultural tool for operations that currently

require the use of pesticides. For example, the fuelwood market may provide an alternative to the use of herbicides currently used to convert stands of low-grade hardwood into commercially desirable conifer stands. Fuelwood harvests could also be employed as a silvicultural tool in the effort to reduce the long-term susceptibility of spruce-fir stands to the spruce budworm. In addition, to the extent that whole-tree harvests remove logging slash that serves as shelter for breeding populations of insect pests, a reduction in the use of insecticides might be indirectly realized.

The developing fuelwood market and the expanded use of mechanized whole-tree chipping operations may ultimately stimulate an increased dependence on monocultural forestry. This would result in the need for increased use of both herbicides and insecticides to suppress undesirable species and insect pests.

At present, it must be emphasized that effects of fuelwood harvesting for the proposed facility on the use of herbicides and pesticides is unknown. The questions posed by these possibilities apply to both fuelwood and other intensive forest management practices. The implications for the forests and related ecosystems of Maine require further research.

3.3.5 Aquatic Ecosystems

Timber harvesting, especially clearcutting, can affect the aquatic ecosystem by changing stream water quality. Most water quality changes likely to result from fuelwood harvesting are discussed in detail in Section 3.3.2. Decomposition of roots, slash, and stumps and accelerated soil erosion and leaching due to loss of plant cover can raise the nutrient concentration in forest streams. This enrichment can stimulate primary productivity, especially algae, and result in a temporary increase in the size and diversity of the aquatic community. Shifts in insect populations away from detrital feeders to algal feeders may occur (Gibbons & Salo 1973). These effects would be particularly noticeable in streams that normally have low nutrient levels, such as cold-water trout streams. In streams that are already

nutrient-rich, there may be a tendency toward eutrophication. Nutrient increases of this kind decline quickly as the cut area becomes revegetated (Corbett, Lynch, & Sopper 1978).

Removal of the tree canopy exposes forest streams to sunlight and can raise the water temperature, which further enhances algal growth and biological oxygen demand. High biological oxygen demand decreases dissolved oxygen, which is needed for respiration; this change can affect the metabolic rate, hatching, development, and migration patterns of aquatic animals. In fish, reduced growth, vigor, and resistance to disease are probable effects of higher stream temperatures (Corbett, Lynch & Sopper 1978). Loss of the protective canopy can also cause lower stream temperatures in the winter.

Increases in erosion and sedimentation can cause a variety of changes. High water turbidity blocks light transmission and reduces primary production. Sediment can fill the spaces of the gravel substrate and reduce oxygen and nutrient circulation reaching bottom-dwelling organisms and fish embryos. Silt can cause inflammation of the gill membranes of fish. Prolonged exposure to concentrations of two to three hundred parts per million of suspended sediment can be lethal (Gibbons & Salo 1973).

Logging debris can present physical barriers to the movement of fish, which can adversely affect spawning activity. Direct destruction of habitats and organisms will result if logs are skidded in stream beds.

While fuelwood harvesting will not require the use of pesticides, the application of herbicides and insecticides to the forest as a result of concurrent activities could adversely affect aquatic organisms. Generally, herbicides will injure aquatic plants only if they are applied directly in or near the stream. Insecticides, however, can seriously threaten aquatic invertebrates especially if heavy rains result in overland flow and sedimentation (Gibbons & Salo 1973).

Changes in stream water quality are heavily dependent on the management of the timber cut. Clearcutting near the stream edge will have the most marked effect. Selective cuts or strip cuts

buffered by a forested area beside the stream will substantially lessen the impacts on the existing aquatic community. Clear-cutting along public waters is prohibited by law in both Maine (Maine Revised Statutes Annotated, Title 12, 4811-4814) and New Hampshire (New Hampshire Revised Statutes Annotated, 224:44-a).

Endangered or Threatened Species

The short-nosed sturgeon is known to exist in Merrymeeting Bay at the outlets of the Kennebec and Androscoggin rivers (Adamus & Clough 1976). The sturgeon has been observed recently in Augusta, where a set of natural falls on the Kennebec River prohibits further upstream migration (Squiers 1979b). In addition, the sturgeon now migrates to the head of tide on the Androscoggin, where the Topsham falls block its upstream passage (Squiers 1979b). The exact locations of the short-nosed sturgeon's spawning sites are not known, although the fish's size limits these sites to large rivers and tributaries. Erosion and subsequent sedimentation caused by fuelwood harvesting in the headwaters of the Kennebec or Androscoggin rivers would be unlikely to impact the sturgeon, since suspended sediment would be diluted to minute concentrations by the time it reached the main rivers. An extraordinarily severe harvest erosion incident occurring along a major tributary close to its mouth could possibly disrupt the sturgeon's spawning grounds. Proper harvesting management would mitigate such a possibility.

Possible changes in aquatic ecosystems are not expected to affect the bald eagle, since slight changes in water quality from upstream harvesting operations would not threaten the total quantity of fish available as food for the eagle. Potential harvesting impacts on nesting sites are discussed in Section 3.3.4.

Species of Commercial and/or Recreational Value

Local populations of commercial and game fish will be threatened if logging procedures are poor. In these instances, deterioration of water quality and changes in aquatic habitat may deplete or eliminate certain of these species from the local area. Species that migrate to cold-water upland streams may find fewer suitable spawning areas. If proper silvicultural practices are

followed, then the overall fishery resource of the area should not be affected.

The occurrence of waterfowl and mammals will be affected more by the physical terrestrial disturbances of logging than by possible changes in the aquatic environment (see Section 3.3.7). Excessive siltation and eutrophication may make some areas unsuitable for habitation by waterfowl and aquatic mammals, but these changes are generally local and temporary.

3.3.6 Air Quality Impacts

Atmospheric emissions resulting from fuelwood harvesting will be caused by wood-cutting activities and the transportation of chips, equipment, and personnel to and from the harvest sites. Emissions related to transportation of chips are discussed in Section 3.5.1. Harvesting personnel will total no more than seventy and will be dispersed at approximately nine cutting sites throughout an area totaling approximately eight thousand square miles. The transportation of personnel and equipment will have no significant regional or local impact on air quality. The air quality impacts relating to fuelwood harvesting are discussed below.

Harvesting and chipping operations for the proposed wood-fired power plant will be conducted simultaneously at sites throughout the harvesting region. The equipment at each site will include various combinations of chain saws, feller-bunchers, skidders, and chippers, which have a combined rating of between five hundred and nine hundred horsepower. The largest operations will include a 22-inch chipper, two or three skidders, and one or two feller bunchers. Smaller operations will employ a 12- or 16-inch chipper and one or two skidders. With smaller chippers, it is common to use a grapple boom operated on a power take-off from a gasoline-powered truck; emissions from the idling truck must be considered (larger chippers typically have an affixed boom loader). In general, the harvesting equipment will be diesel powered, although some models use gasoline engines. Daily and

annual emissions estimates for a range of typical harvesting operations are given in Table 3.3.6-A.

The average annual emissions from each harvesting operation will be relatively small and will be widely distributed throughout a large region. Carbon monoxide from gasoline-powered operations will be the pollutant emitted in the greatest amount. The carbon monoxide emissions will not threaten short- or long-term ambient air quality standards.

The total amount of nitrogen oxide emitted from large harvesting operations will be approximately 8 tons per year and from small operations will be about 2.5 tons per year. The total emissions of nitrogen oxides from nine fuelwood harvesting operations expected to be required for the proposed wood-fired boiler will not exceed 71.1 tons per year. Similarly, harvesting fuelwood for the proposed wood-fired power plant will result in particulate, hydrocarbon, sulfur dioxide, and aldehyde emissions totaling less than 5.0 tons, 25.2 tons, 4.7 tons, and 1.7 tons, respectively. Since these emissions will be produced at widely dispersed sites, the regional impact on ambient air quality will be too small to measure. Adverse local air quality impacts may occur in the vicinity of harvesting operations under certain conditions, however.

During harvesting the chipper is located for periods of several days to several weeks in a forest clearing of two to five acres. Skidders come and go at this clearing bringing trees cut by a feller-buncher or chainsaw operating in adjacent woods. Atmospheric emissions from the harvesting equipment, together with blowing soil and sawdust, will be noticeable. At times, such clearings may be located in valley bottoms or dense forests where normal atmospheric ventilation is restricted. This restriction will be intensified during the occurrence of regional high pressure systems. Under these conditions, concentrations of some criteria pollutants may exceed short-term state or federal ambient air quality standards.

To assess the likelihood of such occurrences, two models were employed to relate the site emissions from a 22-inch chipper to

TABLE 3.3.6-A: DAILY AND ANNUAL EMISSIONS ESTIMATES FOR TYPICAL HARVESTING OPERATIONS

Type of Operation	Particulates	Carbon Monoxide	Hydro-carbons	Aldehydes[2]	Nitrogen Oxides[3]	Sulfur Dioxide
			Daily Emissions[1] *(pounds)*			
Small-scale: diesel Except for gas truck-powered boom loader. Consumes 50 gallons/day diesel and 10 gallons/day gasoline[4]	1.7	54.0	3.5	0.4	24	1.5
Large-scale: diesel Consumes 160 gallons/day diesel[5]	5.3	16.3	6.0	1.1	75	5.0
Small-scale: gasoline 430 h.p. at 0.5 load factor Consumes 10 gallons/day for boom loader[4]	1.2	754.0	27.0	0.8	20	0
			Annual Emissions[6] *(tons)*			
Small-scale: diesel[4]	0.18	5.7	0.37	0.04	2.5	0.16
Large-scale: diesel[5]	0.56	1.7	0.63	0.12	7.9	0.52
Small-scale: gasoline[4]	0.13	79.0	2.80	0.09	2.1	0

1. *Based on EPA emission estimates (from EPA 1976) and typical daily fuel consumption supplied by chip-harvesting operators (Dashnaw 1978; Percival 1978b). Gasoline configuration estimate based on hypothetical equipment.*
2. *Not a criteria pollutant.*
3. *EPA figures assume 100% conversion of nitrogen oxide (NO) to nitrogen dioxide (NO_2). The actual conversion rate in rural areas is limited by prevailing ozone concentrations and will be in the range of 25% to 75% (see Appendix B).*
4. *One feller-buncher, one 16-inch chipper, one skidder.*
5. *One feller-buncher, one 22-inch chipper, two skidders.*
6. *Based on 210 operating days/year.*

TABLE 3.3.6-B: ESTIMATED ONE-HOUR MAXIMUM CONCENTRATION OF CRITERIA POLLUTANTS EMITTED FROM WHOLE-TREE CHIPPERS AT LANDING SITE

	Pollutant	Standard	Type of Standard	Short-Term Average Concentrations Predicted by Model	Concentrations Converted to Standard[1]
BOX MODEL[2]	Carbon monoxide	10 mg/cu m	Federal 8-hour	5 mg/cu m	3.5 mg/cu m
	Nitrogen oxide[3]	100 µg/cu m	Federal annual	11,400 µg/cu m	-
	Particulates	100 µg/cu m	Maine 24-hour	800 µg/cu m	352 µg/cu m
	Sulfur dioxide	1,150 µg/cu m	Maine 3-hour	1,500 µg/cu m	1,350 µg/cu m
	Hydrocarbons	160 µg/cu m	Federal 6 to 9 am 3-hour	1,800 µg/cu m	1,620 µg/cu m
DISPERSION MODEL[2]	Carbon monoxide	10 mg/cu m	Federal 8-hour	0.125 mg/cu m	0.088 mg/cu m
	Nitrogen oxide[3]	100 µg/cu m	Federal annual	290 µg/cu m	-
	Particulates	100 µg/cu m	Maine 24-hour	22 µg/cu m	8.8 µg/cu m
	Sulfur dioxide	1,150 µg/cu m	Maine 3-hour	38 µg/cu m	34.2 µg/cu m
	Hydrocarbons	160 µg/cu m	Federal 6 to 9 am 3-hour	45 µg/cu m	40.5 µg/cu m

1. *This column converts the maximum one-hour concentration predicted by the two models to a figure appropriate for the EPA time period standard most likely to be exceeded. Conversion factors are: 3-hour = 0.9, 8-hour = 0.7, 24-hour = 0.4 (Budney 1977). There is no conversion factor for the annual standard.*
2. *These models are described in Appendix B.*
3. *Assumes 50% conversion of nitrogen oxide to nigrogen dioxide, based on EPA emission factor in EPA 1976.*

TABLE 3.3.9-A: MAINE STATEWIDE AVERAGE MILL DELIVERED PRICE OF BOLTWOOD[1]

(dollars/green ton)

Species	Prices		
	Fall 1977[2]	Spring 1978[3]	Fall 1978[4]
White Pine	$ 14.80	$ 14.60	$ 17.80
Cedar	17.60	16.40	18.60
White Birch	31.20	32.20	35.60
Yellow Birch	30.00	30.80	32.60
Hard Maple	28.80	26.80	28.40
Oak	27.20	29.00	29.60
Beech	19.60	19.20	20.60
Aspen	16.00	16.40	15.00
Soft Maple	19.00	18.20	20.80
White Ash	28.40	32.00	30.00
Pallet	-	-	20.00
Basswood	18.00	-	-
Red Pine	16.00	-	-
Spruce	17.00	-	-
Firewood	15.00	18.90	20.60
White Pine Shingle Stock	12.00	12.00	14.40

1. *Assumes 500 board feet/cord and 2.5 tons/cord.*
2. *Calculated from MFS 1977.*
3. *Calculated from MFS 1978a.*
4. *Calculated from MFS 1978b.*

- no data available.

local air quality. The first model, a "box model," operated under the assumption that wind speeds were negligible and that the air within the forest clearing was replaced once per hour. The second model, a "Gaussian plume dispersion model," assumed a maximum plume height of twenty meters and a constant wind speed of three meters per second to predict concentrations of pollutants at a downwind distance of one hundred meters. Both models assumed that the 22-inch chipper operated continuously at its reported daily fuel consumption rate within a restricted area of two acres. The results of these computations are summarized in Table 3.3.6-B.

From these results, it can be seen that the chipper operation would not threaten any applicable air quality standards at times when even a three meter-per-second breeze (about six knots) was blowing. However, at fuelwood harvest landings where atmospheric ventilation is restricted, emissions may exceed ambient air quality standards on still days when high pressure systems dominate regional weather. Specifically, the 24-hour particulate standards, the 3-hour sulfur dioxide standard, and the 3-hour morning hydrocarbon standard all could be violated. Particulate concentrations will be further intensified under these conditions by soil particles and sawdust from the chipper as well as by emissions from skidders operating to and from the landing. Sulfur dioxide and hydrocarbon concentrations will also be increased by skidder exhaust. The nitrogen oxide concentrations will not exceed present Occupational Safety and Health Administration standards. No short-term state or federal standard for nitrogen oxide has been established.

In reviewing these concentrations, it should be remembered that chippers will operate at a particular site for a period of only several days to several weeks. Further, the conditions of extreme atmospheric stability likely to cause temporarily excessive ambient concentrations of pollutants are generally rare within the harvest region except in deep valleys and seldom last beyond the mid-morning hours in any event.

3.3.7 Forest Practices

The proposed wood-fired power plant will improve the merchantability of wood currently considered "waste," increase the number of highly mechanized harvesting operations in the region, and alter the characteristics of the woods labor force; consequently, the project will cause changes in the region's forest practices.

Wood will be delivered to the proposed plant as low-quality chips, a product that does not demand specific tree form or quality. Portions, sizes, species, and grades of timber that are currently unusable, therefore, will acquire commercial value when the plant begins operating. This increased merchantability will simultaneously improve the economics of forest management and accelerate the need for measures to prevent forest mismanagement.

The addition of a market for low-quality wood chips in the fuelwood harvest region will create an alternative to the traditional practice of harvesting only the highest quality trees and leaving the poorer trees to reestablish the forest. The fuel chip market will make it possible to conduct profitable harvests while leaving high quality trees to accrue significant additional value and restock the forests with young trees from their seed. Thus, the project opens the possibility of greater consideration for the future forest in the planning of timber harvests.

The provision of a market for waste wood and for trees as small as two inches in diameter will also improve the feasibility of timber stand improvement. For example, because small trees thinned from stands in the fuelwood harvest region have typically had no commercial value, investments in forest improvement have been costly and have not yielded returns until the remaining forest has grown for one or more additional decades (Hillstrom & Steinhilb 1976). Consequently, this type of timber stand improvement has only rarely been undertaken. By accepting material from such thinnings, the power plant will accord it merchantable status and thus improve the opportunities for timber stand improvement while lengthening the income-producing portion of the forest rotation. In addition, the project will create a market

for the slash from on-going harvest operations. To be collected economically, however, this slash must be skidded to the forest landing as part of the merchantable portion of the tree and then sorted for shipment to the power plant. It is unlikely that it would be cost-effective to collect slash left on the forest floor for this project.

Potential losses in timber value due to its use for products of lower than the maximum value could occur as a result of this project. Loggers find it operationally simpler to chip all material and to neglect sorting sawtimber and other high-value products during fuelwood harvest operations (Bourassa 1978). Similarly, operators will be tempted to harvest and chip well-formed young trees that might otherwise have grown into high-grade pole or sawtimber. Nonetheless, some chipping contractors today achieve their best economic returns by sorting lumber, pulp, and pole-quality logs and selling these to mills for a higher price than that received for fuel chips (Percival 1978a) (see Section 3.3.9). Likewise, some landowners demand that small, high-quality trees be left to grow into more valuable mature stock. Thus, economic considerations somewhat mitigate the tendency to chip indiscriminately.

Because the power plant will accept low-quality and consequently low-value material, the most efficient means of harvesting and transporting this material must be employed. Experience in this region and abroad indicates that a system employing sawyers or fellerbunchers to shear the trees, large grapple skidders to haul the whole tree to the landing, and a portable chipper to chip the tree and blow it into truck vans will be the most cost efficient harvest method (Rich 1978a). This type of system is significantly more mechanized that the typical system used to harvest wood in the region today.

Highly mechanized harvest operations could result in increased damage to the residual stand and to the forest harvest site. Residual stand damage is often characterized by mechanical injury to uncut trees during felling and skidding operations. The use of large grapple skidders associated with whole-tree har-

vests raises the likelihood of this sort of damage (Hillstrom & Steinhilb 1976). Fellerbunchers, large machines that both cut and pile trees, reduce the likelihood of a falling tree damaging the remaining stand but can themselves abrade or break remaining trees if poorly operated. Careful planning and machinery maneuvering can reduce both skidding and felling damage to acceptable levels (Zasada 1975).

There is popular concern that mechanized whole-tree harvesting is inextricably associated with both clearcutting and overcutting. Because all grades and types of trees are acceptable as fuel, the project will provide an incentive to increase clearcutting. Also, since clearcutting offers one means to improve harvest efficiency (Smith 1962), it is an attractive system to loggers seeking to maximize returns on the high capital and operating costs associated with mechanized operations. However, the resistance to drastic visual impacts and the use of large machinery, which is characteristic of many landowners in northern New England, will continue to act as a restraint on the use of this method (see Section 2.2.8). A number of profitable whole-tree harvesting operations currently practice selective cutting on small landholdings in the Northeast; clearcutting is not necessitated by whole-tree harvesting. Clearcutting, however, may be the most acceptable harvest procedure under some conditions.

A 50-megawatt power plant fueled entirely with whole-tree chips would require the output of an estimated seventeen whole-tree chipping operations working single shifts (Rich 1978a). At present there are five such operations in the fuelwood harvest region. Because the project could more than triple the number of whole-tree harvesting operations in the region, it would provide a highly visible demonstration of the feasibility of whole-tree harvesting on private land holdings. If mechanized harvesting is proven practical and economic on these lands, widespread adoption of these methods for the production of wood chips would be hastened. Nationwide trends indicate increasing reliance on reconstituted wood products made from chips, as well as on the use of wood for energy (USFS 1974). While overcutting (when tree removals

exceed growth) should not result from the current project (Sewall 1978), a successful demonstration could attract other users of wood to the region, an event that would increase the danger of overharvest. Current land management policies in Maine and New Hampshire do not protect against such an outcome.

In the long run, widespread forest industry changes resulting indirectly from the project could profoundly influence forest practices in the fuelwood harvest region. The development of a materials and energy industry based on wood chips rather than logs could lead to management of the forests for fiber rather than timber production. Called biomass farming, this type of management often implies harvesting at much shorter intervals than those presently used. Such practices would obviously alter the aesthetic character of the forest and could change current patterns of land use within it.

Finally, changes in harvest practices associated with the project will affect the responsibilities, independence, and working conditions of those workers employed in the woods. If many contractors find the capital cost of mechanized harvesting equipment prohibitive, the mill or power plant may provide loans or subsidies to assist in the purchase of such equipment. In either case, assistance would diminish the independence of logging contractors, an issue that currently is highly controversial (Granskog & Siegel 1978). Financial assistance and the stable demand for fuelwood chips will serve to strengthen the contractual agreements between loggers and the wood-fired power plant. In sum, the wood procurement labor force for the project may move closer into the direct employment of the mill, a trend which may lead to an enjoining of the mills to provide full labor benefits for woods workers. This outcome could result in higher fuelwood costs.

In addition to affecting the employment status of loggers, the increase in mechanized harvesting caused by the project will redefine the nature of the loggers' jobs and the skills required to do them. Woods workers associated with the fuelwood harvesting will need the skills of heavy equipment operators, in addition

to those of timber fellers. In general, they must possess greater mechanical ability for operation, maintenance and repair of the equipment. Refined supervisory skills, including detailed knowledge of the time/cost factors in the components of a mechanized harvest system, will be required of foremen, in order to maximize the efficiency of the machinery and minimize the cost of fuelwood procurement.

Changed working conditions generally will make woods work more attractive, as operators will experience less exposure to the elements, little direct handling of wood, and reduced safety hazards.

3.3.8 Land Use

The proposed project will not alter the basic land use patterns nor the predominance of forested land in the fuelwood harvest region. However, more intensive harvesting, increased forest management, and the introduction of new harvesting technologies will influence the way the forested land is used.

Intensive forest management requires a network of woods roads for improvement activities and for the extraction of wood. If whole-tree chipping were employed, well-constructed and permanent gravel roads would have to be built for the large chip vans. However, for the most part, the profitability of harvesting wood for energy will not support the construction of these roads. The removal of wood for the proposed project will have to interact synergistically with other potential uses of forest land before landowners can economically invest in construction of a new, expanded road network for their forests.

In addition to their potential to cause erosion and their aesthetic impacts, roads increase access to forest lands (see Sections 3.3.1 and 3.3.11). If the network is expanded, improved access will provide more opportunities for woodland recreation, which could relieve some of the burden on other recreational lands. In remoter areas, greater accessibility may decrease the opportunities for "wilderness experiences." An improved road network could also attract housing development in some areas.

While harvesting for this project will not stimulate road building sufficiently to cause substantial regional changes in land use, some housing development of local importance and concern could take place.

If poorly conducted whole-tree operations became common, the public could react to the resulting deterioration by demanding stricter land-use regulations and more preservation. As a result, less land would be available for commercial harvesting. Well-conducted harvest operations, however, could improve the value of remaining timber and help to counteract any tendencies to convert forest land to other uses.

Changes in forest practices can either enhance or deteriorate the recreational and aesthetic value of forest ecosystems (see Sections 3.3.1 and 3.3.12). More intensive harvesting and management can either increase or decrease habitat for both game and nongame wildlife (see Section 3.3.4), affecting hunting, bird-watching, and other wildlife-related activities. Proper planning of harvest operations can ensure the incorporation of practices beneficial to wildlife.

If harvesting changes the recreational environment of the forest, services supported by tourism will be affected. Restaurants, motels, campgrounds, sporting goods stores, and retail establishments dependent on clients using recreational lands affected by this project may face changes in levels of business as a result of harvesting operations. Carefully conducted operations can improve the aesthetic appearance of the forest while increasing its accessibility, consequently attracting additional recreationists. On the other hand, service establishments could experience sharp declines in business if they were adjacent to or dependent on lands where fuelwood harvesting was conducted indiscriminately.

Indirectly, the proposed plant may influence industrial land use by demonstrating the feasibility of wood-fired cogeneration. Wood fuel could protect users from rising fuel costs and stem the flow of industry out of New England, as well as encouraging regional industrial expansion. In areas with ample fuel supplies,

small parcels of land may be devoted to industrial expansion and associated suburbanization. Thus the proposed project will enhance employment and economic stability in the region and therefore maintain or slightly intensify present industrial and commercial land use. However, the commitment of wood to this project will discourage other wood-using industries from locating in the fuelwood harvest region.

3.3.9 Wood Products Industry

The proposed wood-fired power plant will demonstrate the feasibility and economic viability of collecting, handling, and burning wood for steam and electricity generation. As a publicly funded demonstration project, the plant will attract media coverage and public attention. Construction data, environmental analysis, and economic studies for the project will be available publicly and will provide an incentive for others, including those in the wood products industry, to investigate conversion to wood-fired cogenerating boilers.

In its heating and drying processes, the pulp and paper industry uses 84 percent of all energy consumed by the wood products industry. In the Northeast, oil is the industry's major fuel source, providing 56 percent of the energy consumed (USFS 1976).

Price increases of the past decade and concern over supply reliability have forced the industry to consider alternative fuels. The environmental control costs of burning coal and the limited availability of natural gas in New England present problems similar to those associated with fuel oil. Thus, wood is becoming an attractive alternative for the industry. The use of wood residue as an energy source in new mills is usually advantageous, but retrofitting an existing plant to burn chips requires a large capital investment for the boilers, fuel storage and handling equipment, and air quality control systems (Saeman 1977). The proposed plan will demonstrate the feasibility of increasing

energy self-sufficiency by retrofitting a mill for cogeneration of steam and electricity.

A major drawback to investment in cogeneration is the loss of flexibility in fuel type and energy use. However, with accurate projections of energy needs and relative fuel costs, a cogenerating firm can buffer its production from increasing energy costs and improve the competitive position of its products. In addition, money that would otherwise be drained from the economy in purchasing oil will remain in the local economy (GCC 1978).

Feasibility of Whole-tree Chipping

The project will also demonstrate the feasibility of whole-tree chipping for fuelwood. The proposed wood-fired plant may precipitate an increase in whole-tree harvesting and chipping in the fuelwood harvest region (see Section 3.3.7). Five whole-tree chipping operations presently operate in the area. If all the plant's projected requirement of 680,000 green tons of fuel were harvested each year, between eleven and fifty-four new chipping operations would be needed (calculated from Percival 1978 and Dashnaw 1978). However, since mill residues will probably comprise 40 percent of the plant's fuel supply, chipping operations will number about ten, unless double shifts or extended working hours are instituted.

If whole-tree chipping proves a commercially viable way to produce low-grade fuel chips, other wood industries will be encouraged to institute this harvesting method for the production of both fuel and higher-quality pulp chips. The whole-tree chipping associated with this project will not only demonstrate the viability of the technology but also the acceptability of mechanized harvesting on the small private woodlands prevalent in the region. The absence of slash following a whole-tree harvest may convince previously reluctant landowners to allow harvesting in their forests. A market for low-quality material may also improve the economics of harvesting woodlands previously uneconomic to cut. Combined with the higher yield of whole-tree harvesting over traditional methods, these factors may increase the supply of wood

available for fuel chips, pulp chips, and other products, and thus help to dampen price escalation for wood products.

Regional expertise in whole-tree chipping would attract the interest of particleboard manufacturers and other producers of reconstituted wood products. These products are expected to fulfill a rapidly increasing demand for wood products on a national basis (USFS 1974; Stone 1977). However, the commitment of 680,000 tons of wood to the proposed power plant, combined with commitments to existing and planned wood products mills, may discourage other wood industries from locating within the fuelwood harvesting region.

Competition with Existing Markets

Both fuel chips and roundwood for domestic space heating can be produced from low-quality wood. Although the sources for these products overlap, the price of firewood is higher than that of fuel chips. Retail firewood sells at $45 to $85 per cord ($18 to $34 per green ton), with $51.50 the statewide average ($20.60 per green ton) (MFS 1978b). Increasing reliance on wood for heat seems inevitable; recent and predicted increases in the prices of home heating oil enhance the attractive economics of this fuel. Delivered fuel chips for the proposed plant will cost an estimated $13.50 per green ton (Rich 1978b). Even though the chips sell for lower prices, some wood contractors prefer a relatively stable relationship with an established mill to an uncertain relationship with an unstructured firewood market in which they must advertise and sell wood as well as cut, process, and truck it.

The raw material for bolter, pallet, and shingle mills may overlap with the wood used for fuel chips. In most cases, however, the stricter species and quality requirements and higher mill delivered prices for the wood for these produces will prevent competition with fuel chips for stumpage (see Table 3.3.9-A). However, if fuelwood chip prices rise significantly, certain smaller bolter, shingle, and pallet mills may experience difficulty competing for wood.

Competition for stumpage between pulp chips and fuel chips is also possible. Mill delivered prices for pulp are shown in Table

3.3.9-B. However, pulp mill operations prefer "clean" chips (without bark or dirt), while fuel chips have no specifications of this type. Pulpwood is ordinarily delivered to the mill or concentration yard where it is debarked and chipped. Fuel chips, because of their relatively low value, must be chipped in the woods to minimize transportation costs. Thus, some differentiation in product quality and value does exist.

Since the fuel chips for the proposed power plant will be used by a wood products industry, fuel chip price will be linked to pulpwood prices. The availability of stumpage and labor for harvesting will determine whether or not the price of chips rises with increased demand. Competition for wood could force stumpage prices up; however, as stated above, the availability of stands formerly withheld from harvest may counteract this trend. Logger unemployment and wood availability studies (Sewall 1978) indicate a current surplus in these inputs for wood production. In the short term (a year or less), availability of harvesting equipment may limit wood production and temporarily affect chip prices. Careful scheduling of contracts by the boiler operator during the construction and initial operation of the proposed plant could mitigate this problem.

3.3.10 Socioeconomic Impacts

The proposed wood-fired power plant will consume about 680,000 green tons of wood and wood waste per year (Finn 1978). Approximately 70 percent of this wood, or 480,0 0 gr een tons, will be harvested directly for the plant; the remaining fuel will consist of bark, shavings, and sawdust, available as mill residues.

Employment

The number of harvesters required to produce 480,000 green tons of chips per year depends on the harvesting systems employed, but will be between sixty and seventy (adapted from VanderWerf 1978 and Dashnaw 1978). The project will also require three foresters to supervise the harvesting and ensure that sound forest practices are followed. Thirty-six truckers will be needed to

TABLE 3.3.9-B: MAINE STATEWIDE AVERAGE MILL DELIVERED PRICE OF PULP[1]

(dollars/green ton)

Species	PRICES	
	Four-foot lengths	Tree lengths
White Pine	$ 14.90	$ 12.50
Red Pine	14.90	-
Hemlock	15.50	13.25
Spruce/Fir	19.50	22.00
Tamarack	15.50	13.25
Aspen	13.90	-
Other Hardwoods	-	21.25

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1. From MFS 1978b.

- no data available.

transport the wood and wood waste (see Appendix F) and the equivalent of three or four mechanics jobs and a secretary-bookkeeper position will be created in the region to service the trucking operations (VanderWerf 1978). This brings the total number of persons directly employed in harvesting operations to 114 (see Table 3.3.10-A).

The Bureau of Economic Analysis regional impact model predicts that the stimulation to the economy due to harvesting activities will create approximately 134 indirect jobs in the fuelwood harvest region (see Appendix E). Thus, combined direct and indirect employment will total 248 jobs, an increase in regional employment of 0.07 percent over the 1978 employment level (Noyes 1979; MDMA 1979).

Average annual unemployment in the harvest region totaled 17,060 or 5 percent of the labor force during 1978 (Noyes 1979; MDMA 1979). Truckers, mechanics, harvesters, and indirectly employed persons could all be drawn from this pool. The most significant impact on employment would occur if a program were established to train unemployed persons to operate mechanized harvesting equipment. Most of the harvesting will take place in southern Maine and southeastern New Hampshire; it is unlikely that Canadian woods workers will be employed by the project. If all persons employed directly and indirectly by the project came from those currently unemployed in the region, unemployment would be reduced by 248 persons or 0.1 percent (Noyes 1979; MDMA 1979).

Population

The impact on the population of the region of harvesting and transporting wood chips will be small. Even if all direct and indirect positions created by the project were filled by immigrants into the region, the population would increase only by 248 persons. The 1975 population of the area was 749,362 (Census 1976b). Most harvest-related jobs will be filled locally, however, so population growth will be negligible.

Income

Table 3.3.10-A summarizes the direct income in the form of salaries paid to workers engaged in harvesting operations. It is

TABLE 3.3.10-A: DIRECT INCOME IN SALARIES TO WORKERS EMPLOYED IN HARVESTING OPERATIONS

(1977 dollars)

JOB	SALARY	NUMBER EMPLOYED	TOTAL INCOME
Harvesters	$11,000[1]	70[2]	$770,000
Truckers	20,000[3]	36[4]	720,000
Mechanics	10,400[5]	4[5]	41,600
Secretary	7,800[5]	1[5]	7,800
Foresters	12,000	3	36,000
TOTAL		114	$1,575,400

1. *Derived from Census 1976a.*
2. *Derived from VanderWerf 1978 and Dashnaw 1978.*
3. *Source: Adler, Blakey, & Meyer 1978.*
4. *Source: Appendix F.*
5. *Source: VanderWerf 1978.*

estimated that $1.6 million will be paid annually to employees of firms supplying or shipping wood to the proposed wood-fired power plant.

Stumpage fees paid to landowners will provide another source of income. The average stumpage fee paid for firewood in the region is approximately $1.96 per green ton (MFS 1978b). At this rate, stumpage fees paid annually as a result of the facility would total about $940,000. Low-quality millwood residues can be obtained for an average of about $4.50 per ton without shipping (Hewett 1978). Annual regional income from this expenditure will total $800,000.

While harvesting equipment is not manufactured in the fuelwood harvest region, retailers do offer such equipment for sale. Assuming that the average lifetime of harvesting equipment is about five years and that equipment is acquired at about the same rate each year, retail markup on harvesting equipment necessary to fuel the project would return about $169,000 to the regional economy annually (see Appendix E for assumptions about harvesting equipment).

Chip vans for the project are expected to be purchased outside of the fuelwood harvest region. However, diesel fuel purchased for the operation of both harvesting equipment and chip vans will result in revenues for retailers of the region. Harvesting equipment for the project will require about 400,000 gallons of diesel fuel annually (Percival 1978b; Dashnaw 1978), while trucks transporting the chips will use a total of about 440,000 gallons each year (TRB 1977). Retailers and regional shippers of diesel fuel each receive about 5 percent of the selling price of diesel fuel (VanderWerf 1978). The regional economy will receive a direct stimulus of about $50,400 annually from this source.

The direct wages and salaries paid for fuelwood harvest and transportation will stimulate indirect income in the regional economy through an economic multiplier effect. The Bureau of Economic Analysis Regional Impact Model predicts that the direct

expenditures discussed above will stimulate an additional indirect regional income of $4.3 million annually (see Appendix E).

State Revenues

As a result of harvesting for the proposed project, the state of Maine will receive additional tax revenues from personal income tax on salaries and stumpage fees, from sales tax on direct and indirect purchases, and from vehicle registrations and excise taxes. New Hampshire has neither a personal income tax nor a sales tax, and chip vans servicing the proposed plant are most likely to be based in the state of Maine. Therefore, it is unlikely that New Hampshire will receive additional tax revenues as a result of this project.

Estimated personal income tax revenues to the state of Maine could total about $113,000 (calculated from CCC 1978) if all direct and indirect salaries and stumpage fees are paid to Maine residents (see Appendix E). As it is almost certain that some wood will be harvested in New Hampshire, the actual increase in state revenues will probably be somewhat smaller.

The state of Maine will also receive revenues from sales tax on direct purchases for items used in the harvest and transportation of wood, on indirect purchases made possible by the harvesting activity, and on trucks used for the transportation of chips. These amounts would total about $84,000, $180,000, and $17,000 respectively, for a combined state revenue of $243,000 (calculated from Cleaves 1978). The state fuel tax on diesel fuel consumed by the project should return about $40,000 (calculated from CCC 1978). Appendix E describes the derivation of these estimates.

Finally, registration fees and excise taxes paid on chip vans will generate additional state revenues. These are projected to provide annual state revenues of about $25,000 each (calculated from CCC 1978).

State and Local Expenditures

Harvesting for this project is not expected to draw logging operators from outside of the region and is therefore not expected to impact significantly on public expenditures for housing, educa-

tion, or other community services. Even if all 114 workers to be employed in harvesting operations were to immigrate into the region, these workers would live in many communities scattered throughout the harvest region and impacts on social services would be too dispersed to measure.

Loggers have the highest work-related injury or illness rate of all occupations in Maine, however (MDMA 1976). The annual injury rate for loggers in 1976 was 27.5 per 100 full-time workers employed. Of these 27.5 accidents, 15.5 resulted in work time lost (MDMA 1976). The increased logging employment of sixty to seventy positions created by this project will cause approximately twenty additional injuries requiring treatment annually. This accident rate will not stress existing hospital capacity in the fuelwood harvest region.

Highway Maintenance Expenditures

Projected increases in state highway maintenance expenditures are discussed in detail in Appendix F. Chip vans of approximately 80,000 pounds gross vehicle weight are expected to deliver chips to the proposed wood-fired power plant. Approximately 25,000 truck trips are expected to culminate at the plant site annually (see Section 3.5.3).

Projection of the highway costs resulting from chip transportation depends on the total vehicle miles traveled, the types of roads driven, and the extent of operations during the spring thaw season. Greatest uncertainty in such projections, however, stems from the uncertainties inherent in studies predicting the actual impact of trucks on highways. It is expected that road maintenance impacts resulting from chip transportation would not exceed $222,000 annually and could be as low as $7,400 each year (Adler, Blakey & Meyer 1978). Total highway maintenance costs in 1977 were approximately $41 million for Maine (MDOT 1978) and $19 million for New Hampshire (NHDPW 1978).

3.3.11 Archaeological, Historical, Cultural and Aesthetic Resources

Aesthetic

Commercial timber harvesting results in alteration of the landscape. Clearcutting produces the greatest aesthetic impacts, especially in the years immediately after harvesting, before regeneration is obvious. Clearcuts are considered visually unattractive when large tracts of land are denuded and entire landscapes of slash and stumps created. If clearcutting is confined to strips and patches of varying sizes and irregular shapes, in harmony with the landforms and traditional land uses, visually appealing contrasts between open and closed spaces are created and the forest's character is retained (Brush 1976). At times, clearing may open up vistas or reveal unusual natural landforms (Noyes 1970). In most cases, however, forested buffer strips should be located between clearcuts and public roadways, recreational waterways, or ocean shoreline. Laws regulating timber harvesting in these areas have already been established in both New Hampshire and Maine (see Appendix H). Such laws define the maximum percentage of trees that can be harvested within a given distance of roadways and shorelines. Various types of clearcuts are illustrated in Figures 3.3.11-A-C.

The visual impacts of seed-tree and shelterwood cutting are less severe than those of clearcutting. In the former case, a few trees are retained as a seed source; in the latter, the overstory is removed gradually over time, in two or three cuttings, so that some forest cover is continuously maintained.

Selection cutting and thinning both involve the removal of individual selected trees. In these cases, harvesting eliminates the visual impact of lower-quality and deformed trees and reduces crowding, which permits sunlight to penetrate the forest canopy. These cuts often create a park-like environment. A thinned forest may also reveal and frame vistas and landforms (see Figure 3.3.11 D).

Certain guidelines for minimizing aesthetic impact are applicable to all harvesting methods. Tree stumps should be cut

FIGURE 3.3.11-A: VIEW OF NEW AND IRREGULARLY SHAPED CLEARCUT ON DISTANT MOUNTAIN SLOPE (*credit: U.S.D.A. Forest Service*)

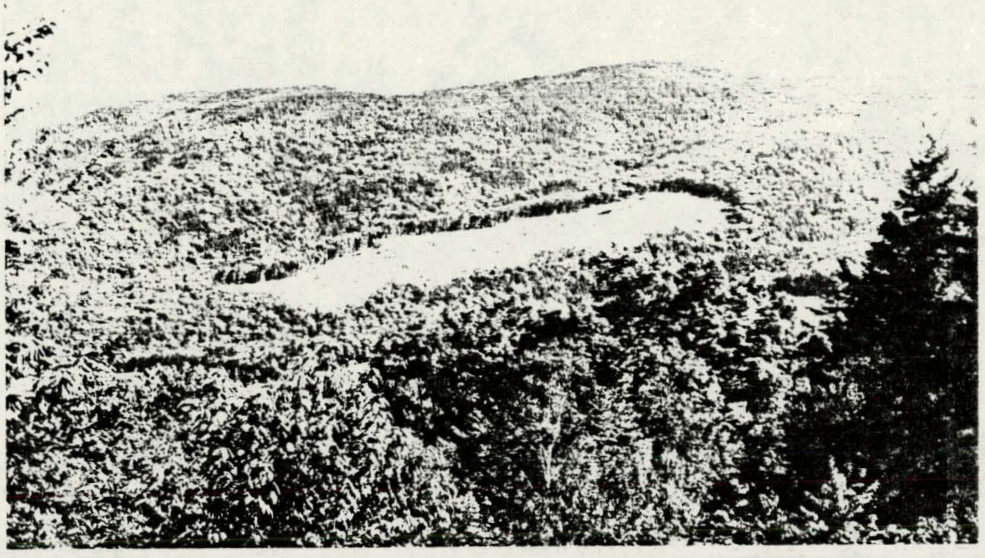


FIGURE 3.3.11-B: CLOSE-UP VIEW OF NEWLY HARVESTED STRIP CUT



FIGURE 3.3.11-C: VIEW LOOKING INTO 3-YEAR-OLD CLEARCUT.

Note height of regeneration.

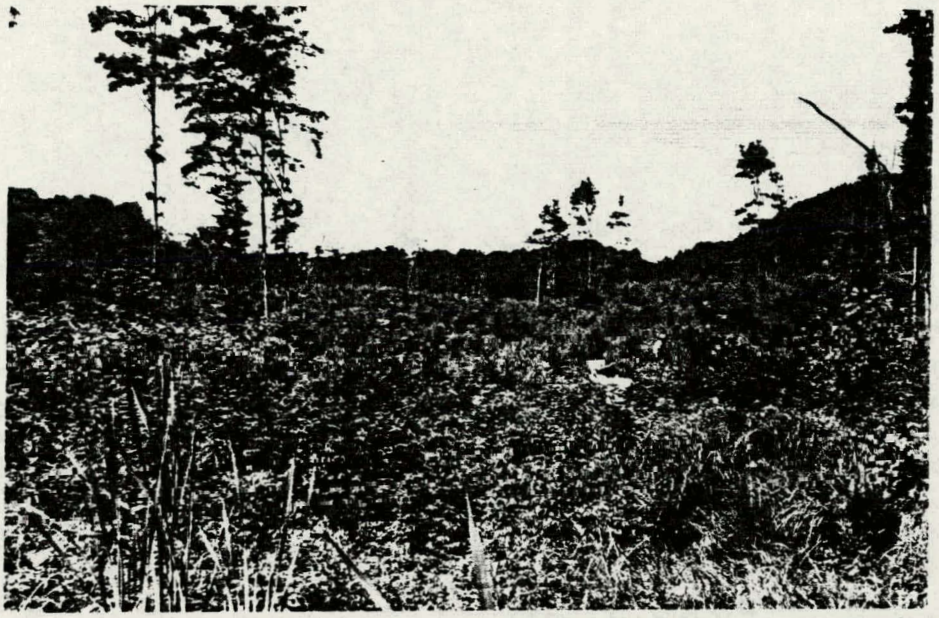
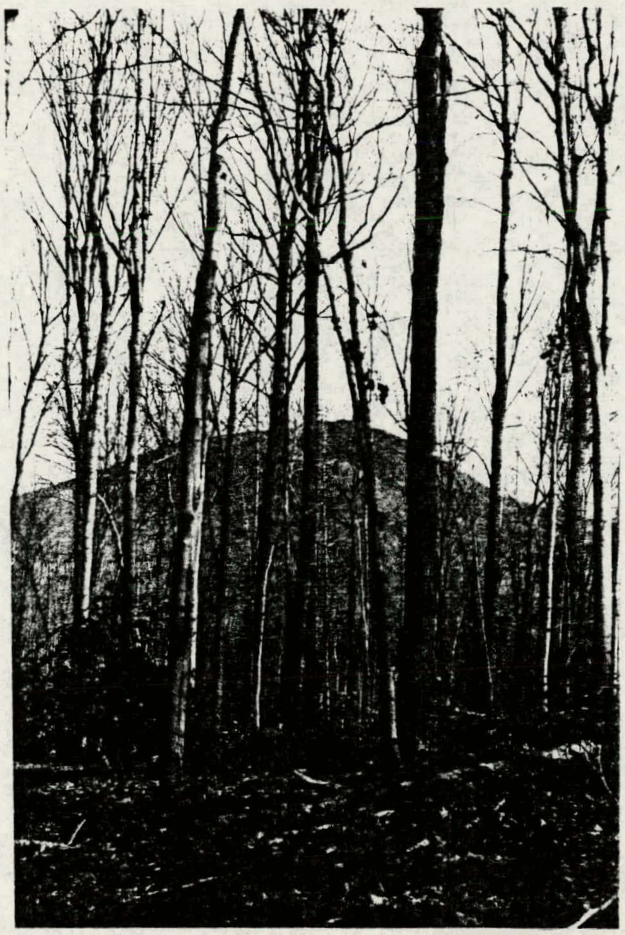


FIGURE 3.3.11-D: SELECTION CUT REVEALS VIEW OF MOUNTAIN IN BACKGROUND



as close as possible to the ground. Mechanized harvesting has an advantage in this respect, for feller-bunchers are able to shear trees closer to the ground than chainsaws can. Aesthetics can be improved through removal of discarded materials such as tree tops and branches (Noyes 1970). The use of wood as a fuel supports this objective by providing a market for the wood residue and therefore creating an incentive to remove it from the forest.

Other components of timber operations may impact forest aesthetics. Upon termination of logging, landing sites are often left as highly compacted eyesores, characterized by slash piles and chipping debris. Visual impacts can be lessened by locating landings out of sight of public roads. The construction and preparation of truck roads and skid trails may also adversely affect aesthetics. In this case, impacts can be lessened by decreasing the width of road cross-sections and clearings, by revegetating cut-and-fill slopes, and by using logging systems that require fewer roads and wider road spacings (Gardner 1978). Unsightly erosion along roads can be avoided through gradient controls, water diversion and retention methods (see Section 3.3.1). Figures 3.3.11-E and -F illustrate the aesthetics of good and bad logging road management.

Archaeologic

Timber harvesting can damage archaeologic remains, as such resources are normally found within the top six inches of mineral soil or immediately beneath the litter layer (see Section 2.2.10). Damage is most apt to occur where archaeologic sites coincide with truck road and skidding networks. Truck road construction severely disturbs the top layers of mineral soil and may damage or destroy archaeologic sites and artifacts. Compaction by harvesting equipment and erosion can also disturb soil layers and adversely impact archaeologic resources (see Section 3.3.1).

The context of an archaeologic site is of greater scientific and historical value than its contents. If the stratigraphy and geology of a site are disturbed, the value of even well-preserved artifacts is lost. Thus, care should be taken in ensuring the protection of both the site and surrounding area where archaeologic

FIGURE 3.3.11-E: 3-YEAR OLD TRUCK ROAD ON WHICH REGENERATION IS TAKING PLACE

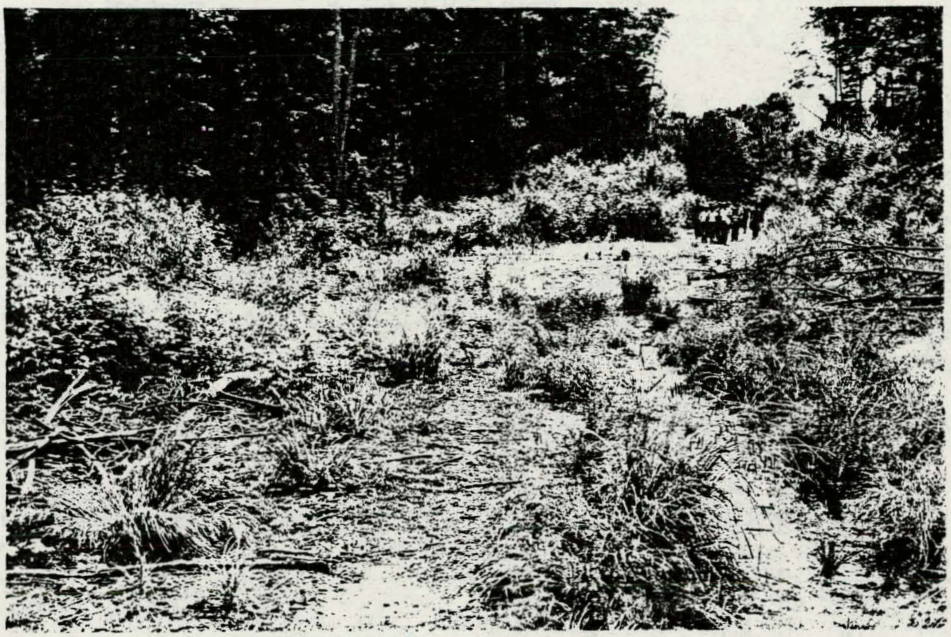


FIGURE 3.3.11-F: VIEW OF SKID TRAIL ON WHICH ACCELERATED EROSION HAS OCCURRED



remnants are found.

Many archaeologic sites are located along inland waterways and the ocean shoreline (see Section 2.2.10) and are partially protected by Maine and New Hampshire laws regulating harvesting in these areas (see Appendix I). However, other sites are neither located in protected areas nor easily recognizable (Spiess 1978a). Although both the Maine and New Hampshire Historic Preservation Office have access to files of known archaeologic sites, very little of the states' land area, especially the fuelwood harvest region, has actually been surveyed (Spiess 1978b). Therefore, to avoid destruction of valuable archaeologic resources, preliminary surveys of harvest sites and their road networks by a professional archaeologist are advisable. Because of personnel and fund restrictions, however, these surveys are not commonly conducted.

3.3.12 Recreation

The intensive harvesting and new technologies that the proposed action will precipitate could alter the balance between recreational and industrial uses of the forest, if harvesting is not carefully planned and executed. Because recreation is closely linked to Maine's forest and rural environment, changes in the landscape will potentially impact tourism. Intensive harvesting techniques, such as clearcutting, could deteriorate the visual resources of the fuelwood harvest region (see Section 3.3.11). Careful planning of operations can mitigate negative visual impacts. Beneficial results can be obtained if harvesting opens vistas or creates openings that improve wildlife viewing. Whole-tree harvesting for selection cuts or thinnings could create a park-like forest since slash is removed. This may enhance recreational activity.

If road networks expand with intensive forest management, access to backcountry areas will increase. Cross-country skiing, hiking, snowmobiling, horseback riding, and other backcountry recreation may be heightened. Road upgrading may lead to recreational home development of local importance (see Section 3.3.8).

Roads, however, could detract from the "wilderness experience" important to some recreationists.

Changes in recreational activity could affect restaurants, campgrounds, and other services associated with tourism. This could result in land use changes (see Section 3.3.8).

Poorly conducted harvesting operations that lead to erosion and siltation of streams could degrade fishing and other water-based recreation. The attractiveness of second homes, which are often located on waterfronts, would be lessened by deterioration of water quality. These impacts would be temporary, limited to a one- to five-year period during and immediately following mismanaged harvest operations. These problems are easily prevented by proper harvesting practices and erosion control techniques (see Section 3.3.2).

Hunting and wildlife observation may be improved or degraded by harvesting (see Section 3.3.4). If forest openings created by cutting produce young sprout growth and increase "edge," wildlife diversity and numbers may temporarily increase. This impact can be enhanced by planning harvesting to create dispersed openings to maximize wildlife habitat. Habitat for species that require large tracts of mature woodland, like the bobcat and the black bear, will likely be difficult to maintain in areas intensively managed for wood products. Large clearcuts usually reduce wildlife habitat because cover is removed over a large area.

3.3.13 Pollution Incidents

The impacts of fuelwood harvesting discussed in Sections 3.3.1 through 3.3.12 are common to logging operations. Occasionally, however, unexpected events occur which cause severe environmental damage. These events are unlikely and their chances of happening as a result of harvesting for the proposed project are small.

Severe erosion and subsequent degradation of downstream water quality as a result of high sedimentation levels sometimes occur when skid trails or logging roads are poorly designed. A great

amount of rainfall in a short period of time sometimes hastens such an event. Water quality and aquatic ecosystems generally suffer most from such an erosion incident. Plant and fish life in streams and ponds may be disturbed or destroyed. Such impacts are usually temporary and aquatic ecosystems generally regain their vitality within a few months to a few years. During that time, the aesthetic quality of adjacent areas may be affected and fishing and other water-based recreation may become undesirable. Similar impacts may occur on a less dramatic scale as a result of skidders crossing or driving up and down streams. Severe erosion also affects the terrestrial ecosystem from which the soil is removed. Huge gullies sometimes develop, which are unattractive and make passage by vehicles impossible. Loss of topsoil prevents or greatly slows regeneration of abandoned skid trails and less dramatic erosion may persist into the indefinite future.

Air quality, on occasion, may also deteriorate to the point where state and federal air quality regulations are violated. When harvesting equipment operates in valley bottoms or dense forests, where normal ventilation is restricted, occurrences of regional high pressure systems may cause violations of the 24 hour particulate standard, the 3-hour sulfur dioxide standard, and the 3-hour morning hydrocarbon standard (see Section 3.3.6). Such violations will be highly localized and short-lived.

Rarely, fire may occur as a result of harvesting. Faulty spark arresters on harvesting equipment, careless disposal of cigarettes or matches, or careless use of repair equipment (such as welding torches) can result in forest fire. Forest fires are quite infrequent in northern hardwood forests. However, when they do occur, the forest and adjacent ecosystem may be destroyed and the long-term productivity of the site may be decreased. Commercial value of timber and recreational land may be lost. Aquatic ecosystems may be impacted as a result of erosion, removal of shading, or operation of fire-fighting equipment. The likelihood of extensive fires resulting from the fuelwood harvesting for this project is reduced because the roads suitable for chip vans also provide ready access for fire-fighting equip-

ment. Although large forest fires have occurred in the fuelwood harvest region in the last 50 years, the fire control abilities of local towns and the Maine Bureau of Forestry have been greatly improved.

Damage to the forest ecosystem can occur as a result of unplanned degradation of harvest sites. For instance, some sites in Vermont with southerly aspects have experienced delayed regeneration following summertime whole-tree chipping operations. Sites on which whole-tree chipping was conducted too frequently could experience substantial declines in the nutrient pool and long-term forest productivity (see Sections 3.3.3 and 3.3.4). Such events can be avoided if harvest operations are carefully planned.

The aesthetic environment may be unacceptably degraded either during or after harvesting operations. Operations carried out in close proximity to recreation areas or homesites may create visual or auditory disturbance. Denuded areas -- particularly on hillsides -- or areas where slash is left behind may create eyesores for some time after harvest. In the northern hardwood forest, however, regeneration usually occurs quickly. Abandoned fuel cans, equipment, landing sites, or other trash all can deteriorate woodland aesthetics.

Accidental spills of lubricating oil or diesel fuel may occur. Diesel fuel is reasonably volatile and is unlikely to have long-lasting effects on vegetation, wildlife, or water quality, although individual organisms directly impacted by the spill may be killed. Lubricating oil is not volatile and may linger in the environment -- particularly in ground or surface waters. In this case, damage to the aquatic life on the bottoms of streams or ponds could occur. If harvesting operations are carried out close to homes, it is possible that wells could be affected. Harvesters for this project are not expected to carry more than 250 gallons of diesel fuel and 55 gallons of lubricating oils.

3.4 IMPACTS OF RESIDUE USE

3.4.1 Impacts of Using S.D. Warren's Residues

The proposed wood-fired steam electric power plant will burn approximately 200,000 tons of wood and bark residues annually. These will be purchased from a variety of pulp and paper and wood products manufacturing companies in Maine and New Hampshire. Approximately 50,000 tons of residue per year will be provided as a result of the shutdown of S.D. Warren Company's bark boiler. The main impact of burning S.D. Warren's wood residues in the new facility, rather than in the existing bark boiler, will be an improvement in air quality resulting from the improved efficiency of the particulate pollution control equipment in the new plant. The air quality impacts and trade-offs of operation are described in Section 3.2.1. In addition, the proposed wood-fired boiler system's improved efficiency and cooling system will reduce the use of water from and discharge of heat to the Presumpscot River, per unit of wood residue combusted. The water quality impacts of operation are described in Section 3.2.2.

3.4.2 Impacts of Using Other Residues

Apart from the S.D. Warren supply, the residue is expected to come from pulp and paper and wood products companies who currently burn or landfill their residues. The effects of using these residues would be felt as reductions in open burning and landfilling.

Air Quality

Wood and bark residues in Maine are generally burned in cone burners, tipi burners, or incinerators. These burners have no particulate control devices and therefore release relatively large quantities of particulates to the atmosphere. The combustion of wood residues in the proposed wood-fired plant will result in a much lower discharge of particulates per unit of wood burned, since the boiler's emissions will be controlled by equipment that collects approximately 97 percent of the particulates in the

smoke stream (see Section 3.2.1). Every ton of residue burned in the proposed plant instead of in open burners will reduce particulate emissions to the atmosphere (see Table 3.4.2-A). The improvement in ambient air quality resulting from this reduction will vary but in many cases there will be significant improvement in local air quality. Small reductions in fugitive dust from open residue piles may also be realized in some locations.

Quantities of other criteria pollutants emitted from the proposed plant may be the same as or slightly more than those emitted if the residue were burned as at present. Sulfur dioxide emissions should remain about the same. Available data on wood combustion under varying conditions does not allow a comparison of the release of nitrogen oxides, hydrocarbons, or carbon monoxide. However, as the proposed boiler must meet the applicable standards for the release of these pollutants, any increase in their release should not result in a deterioration of air quality that would equal or outweigh the improvement gained by reducing particulate emissions.

Land and Water Quality

Wood and bark residues that are disposed of in open dumps and landfills use valuable space and create sources of water pollution. Although wood products residues are only part of the total solid waste disposal problem in Maine, reducing the amount of solid waste and recovering energy from what remains is a primary objective of the Maine "Plan for Solid Waste Management" (Maine News 1979). Use of wood residues in the new facility will reduce the amount of landfill and dump space needed for residue disposal and, in some cases, reduce water pollution resulting from runoff and leaching of residue piles and landfills. The main water pollutants from wood residues are organic acids and organic particulates, which increase biochemical oxygen demand in the receiving waters.

TABLE 3.4.2-A: PARTICULATE EMISSIONS FROM COMBUSTION OF WOOD RESIDUE IN TWO MODES

	EMISSIONS *(pounds/ton of residue)*	
	Without Particulate Control Equipment	With Particulate Control Equipment[1]
Bark[2]	50	1.5
Wood/bark[2]	30	0.9
Wood[3]	5-15	.15-0.45

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1. *Assumes 97% collection efficiency of particulate control equipment on proposed plant (Meffert 1978).*
2. *Moisture content 50%.*
3. *Dry, clean sawdust shavings and ends without bark. Moisture content 5-15%.*

Source: EPA 1976.

3.5 TRANSPORTATION IMPACTS

3.5.1 Transportation Needs

The 680,000 tons of green wood consumed annually by the proposed wood-fired power plant will be transported from the harvest region to the plant primarily by large chip vans (JPR 1979). The final plant design will also include provision for receiving up to 15 percent of the fuelwood by rail (JPR 1979; Rust 1979). If the wood were transported entirely by truck on 250 working days per year, the plant would receive one hundred truckloads of wood per day. With 15 percent of the wood shipped by rail, an average of seven boxcar loads and eighty-five trucks will arrive daily. Appendix F provides a detailed description of the assumptions underlying these conclusions. Removal of boiler ash will require periodic truck and/or rail traffic to an industrial landfill site. Although the location of the site is not yet known, the transportation requirements will be small.

3.5.2 Impacts of Rail Transport

The two principal types of impacts to be expected from rail transport operations in Westbrook and the fuelwood harvest region would be increased air emissions and noise. While studies of increased rail traffic have investigated the effects of changes in routes, schedules, locomotives, types, or speed, studies have not quantified the impacts associated with a modest increase in the number of boxcars hauled. Generally, an increase of seven boxcars per day being hauled into and out of Westbrook should have negligible impacts. Studies show that air emissions from rail transport are extremely small when compared to total emissions in industrial areas (Corvetti 1978). In addition, wood-chip boxcars are relatively quiet; locomotives and whistles produce the noise that may lead to community reaction (Corvetti 1978). Power plant rail transport operations should not affect locomotive or whistle noise levels and hence noise should not increase noticeably. However, if

other rail freight volume increases, the chip cars for this project may contribute incrementally to expanded rail schedules or required locomotive power and thus indirectly increase community noise levels and locomotive emissions.

3.5.3 Impacts of Truck Transport

Congestion

Maine Route 25, U.S. Routes 2, 202, and 302, Interstate 95, and the Maine Turnpike will be the routes most heavily travelled by trucks transporting wood chips to the proposed wood-fired power plant (Dutton 1978). Average traffic on each of these routes is at least several thousand vehicles daily (MDOT 1974). Adding up to one hundred trucks to the current traffic flow will, in general, result in a small percentage increase in total traffic.

The impact on traffic congestion, however, does not depend solely on the total amount of additional traffic, but is largely affected by the timing of the traffic. If volumes during any particular time period exceed the traffic capacity for that period, congestion will result. Congestion impacts in Westbrook and in towns in the fuelwood harvest region would be most severe if traffic were added during the one- to two-hour periods in the morning and afternoon which correspond to peak work trip commuting times. The worst case situation would occur if all thirty-six trucks expected to be used for the project (each making three trips per day--see Appendix F) arrived at the plant site around 7:30 a.m. or between 3:00 and 4:00 p.m. The Cumberland Street Bridge and the traffic triangle at the intersection of Cumberland and Main Streets would be the points of greatest congestion in this case and traffic could be delayed while trucks negotiated turns into the plant site and around the traffic triangle (see Appendix F). Because trucks have an effect on traffic flow equivalent to 2.0 to 2.5 cars, other congestion problems could be experienced at the signalized intersections in Westbrook (Baerwald 1965). In general, however, limited fuelwood unloading capacity

at the plant site will discourage concentrated arrivals of truckers at any time of day. Furthermore, site plans for the wood chip pile location include construction of an access road from Park Road to the truck unloading facilities. This plan would reduce traffic along the more congested Main, Bridge, and Cumberland Streets while increasing traffic along Park Road. The existing congestion problems at the traffic triangle and the Cumberland Bridge would be relieved.

In the fuelwood harvest region, it is expected that trucks will travel different routes at various hours of the day. The likelihood of many wood chip trucks traveling along one route at the same time is small, since harvesting activities will be dispersed throughout a region with a fifty-mile radius.

Bridge Maintenance

It is impossible to quantify the impact of increased truck traffic on bridges in the fuelwood harvest region without knowing the routes such trucks will travel. However, several general statements can be made. Most of the state-maintained bridges in the region are currently in good condition for handling legal loads of 80,000 pounds or less (Dutton 1978; Sirois 1978). Wood chip trucks may travel these bridges without noticeably affecting bridge deck deterioration in the short run. Some state-maintained bridges in the area are not in good condition, however. These bridges are usually posted to accommodate only vehicles weighing less than given load limits. Assuming that truckers drive across bridges only when it is legal to do so, state-maintained bridges should not be adversely affected by an increase of up to one hundred trucks per day traveling over them (Dutton 1978; Sirois 1978).

Many town-maintained bridges could be seriously affected by increased truck traffic in the fuelwood harvest region. Such bridges are often old and in poor condition; they are generally not designed to handle loads such as those imposed by trucks carrying wood chips (Dutton 1978). These bridges are thus subject to severe deck deterioration or possible collapse caused by heavy truck traffic unless they are posted and truckers drive legally. The collapse or closure of a bridge in a small town may lead to

serious congestion along alternate routes as well as negative community reaction to the resulting inconvenience.

In Westbrook, the impact of wood-chip truck traffic upon local bridge conditions is expected to be negligible. The town bridges currently handle similar truck loads and they are adequately designed to handle legal loads (Stearns 1978). Increases in traffic along any bridge will eventually add to bridge deck deterioration, but the effect is long-term and difficult to quantify due to the number of other factors (such as weather) which add to such deterioration.

Road Maintenance

Increased truck traffic may cause road surfaces to deteriorate in Westbrook and the fuelwood harvesting region and cause increased maintenance costs. The use of a procedure developed by Adler, Blakey & Meyer (1978) predicts that an increase of one hundred trucks per day loaded to 80,000 pounds on the highway system in the fuelwood harvest region will lead to increased annual maintenance costs ranging from $7,400 to $222,000. If the maximum legal weight limit for five-axle trucks were increased to 90,000 pounds, annual road maintenance costs resulting from this project would range from $12,300 to $368,000 (see Appendix F). During fiscal year 1977, highway maintenance expenditures for the states of Maine and New Hampshire totaled $41 million and $19 million, respectively.

Air Quality

Trucks hauling fuelwood for the proposed wood-fired power plant will travel annually a total of approximately 200,000 miles at an average speed of 19.6 miles per hour within Westbrook city limits and 2.3 million miles at an average speed of 45 miles per hour throughout the fuelwood harvest region (see Appendix F). Composite emission factors for carbon monoxide, hydrocarbons, and nitrogen oxides were computed using the federal test procedure (see Appendix F). Particulate and sulfur dioxide emission factors were taken from the Compilation of Air Pollution Factors (EPA 1976). Total expected annual emissions in Westbook and the fuelwood harvest region from the chip van fleet for the proposed

power plant are shown in Table 3.5.3-A and compared with existing sources of emissions in those area.

The Maine Department of Environmental Protection Implementation Plan for Air Quality Control (MDEP 1972) outlines general strategies for control of significant emissions in each of the Air Quality Control Regions (AQCR). For the Metropolitan Portland Region, control of particulates and sulfur dioxide emissions are suggested (MDEP 1972). No control strategy is recommended for carbon monoxide, hydrocarbons, or nitrogen dioxide. All regions in the state of Maine are classified priority III (low priority) for these pollutants as a result of assumed existing low concentrations and legislated motor vehicle emission standards (MDEP 1972). Thus, the air pollutants of most interest are sulfur dioxide and particulates. As Table 3.5.3-A demonstrates, expected emissions from the truck fleet will be extremely small when compared with the existing levels of emissions from stationary sources in the region. For the most critical pollutants, sulfur dioxide and particulates, increases over the Portland Air Quality Control Region and over Westbrook stationary sources will be on the order of 0.01 percent.

Hydrocarbon emissions from the trucks appear to be the most significant of all categories; these approach 1.5 percent of the Westbrook current stationary source emissions and 0.2 percent of Portland AQCR emissions. Both of these figures overstate the significance because the Westbrook "current emissions" include only stationary sources (other sources usually contribute more hydrocarbons) while the Portland AQCR includes only part of the harvest region.

Noise

Transporting wood with heavy vehicles over public routes may have serious consequences because of the increased noise level along the roadway. Noise may be a nuisance to nearby persons in their work, domestic activities, or recreation. The intrusion may also have adverse economic consequences: a noisy location may be undesirable as a place to work, shop, or live. However, quantitative relationships between noise levels and the degree of

TABLE 3.5.3-A: COMPARISON OF PROJECTED TRUCK EMISSIONS TO CURRENT AREA EMISSIONS

(tons/year)

	Current Westbrook Stationary Sources	Projected Added Emissions in Westbrook	Current Portland AQCR	Projected Added Emissions in Portland AQCR
Particulates	1,700	0.3	11,000	3.3
Sulfur dioxide	3,900	0.6	32,000	7.1
Carbon monoxide	NA	5.8	11,000	22.1
Hydrocarbons	61	1.0	3,300	6.5
Nitrogen oxide	1,200	4.7	8,800	67.0

NA - not available.
Adapted from Sproul & Woodard 1972; EPA 1976.

economic effect have not been developed. A more general approach is to analyze the effects that new noise levels would have on the surrounding community.

The noise generated by a vehicle is primarily of two types: engine noise and tire-roadway interaction noise. Engine noise is highest during periods of acceleration or in hill climbing. Tire-roadway interaction noise dominates on the open road where little acceleration is necessary. It varies with vehicle velocity, tire type, and road surface (Galloway, Clark & Kerrick 1969). The extent of truck noise depends on surrounding topography and landscaping. Different terrains and landscapes could mitigate, amplify, or channel noise from highway traffic (Kugler & Piersol 1973).

In order to predict noise increases generated by a wood-fired power plant's truck fleet, a recent study (Adler, Blakey & Meyer 1978) used a procedure recommended by the National Cooperative Highway Research Program (Gordon et al. 1973). This procedure estimates either noise levels at specified distances from the roadway or distances from the roadway that specified noise levels are attained. The study explored the effects of various levels of additional truck traffic on noise levels for highways with differing current travel volumes. The results indicate that, for a roadway carrying a moderate traffic load of approximately five thousand vehicles per day, such as Bridge Street in Westbrook, with 620 vehicles in the peak hour and 4.5 percent of trucks, an increase of one hundred trucks per day (ten per hour) would raise the noise level exceeded 10 percent of the time by 1.1 decibels at one hundred feet from the roadway from 67.9 to 69.0 dBA. A road with relatively low traffic volume (one thousand vehicles per day, 6 percent trucks) would experience a noise increase from 60.7 to 63.3 decibels with an addition of one hundred trucks per day.

Complaints from sound levels below 70 decibels elsewhere would be rare (Beaton & Bourget 1968). The predicted noise levels are acceptable exposures for all land uses except hospitals (see Table 3.5.3-B). A possible concern is the movement of additional trucks past the hospital on Park Road. Average daily traffic on

FIGURE 3.5.3-B: EXAMPLE OF RECOMMENDED MAXIMUM NOISE LEVELS

LAND USE	TIME OF DAY	RECOMMENDED MAXIMUM MEAN SOUND PRESSURE LEVEL *(dBA)*[1] PROPERTY LINE	INSIDE STRUCTURE
Residential (single and multiple family)	Day	70	65
	Night	65	55[2]
Business, commercial, industrial	All	75	65
Educational institutions	All	70	60
Hospitals, rest homes	Day	60[3]	55
	Night	50[3]	45
Public parks	All	70	55

1. *Decibels on the A-weighted scale.*
2. *Air-conditioning systems commonly operate at 55 dBA. For non-air-conditioning residential structures, it may be desirable to reduce this value by 5 dBA.*
3. *Expected ambient noise level.*

Source: TTI 1970.

Park Road is approximately 3,700 vehicles per day, but there are no estimates of current truck traffic on that road (PACTS 1978). Since the maximum recommended outside exposure for hospitals is 60 decibels, noise at the hospital could become a problem with additional truck traffic.

Impacts of Construction Vehicles

At its peak, construction activity will involve 610 workers (see Appendix E). Assuming a conservative auto occupancy of 1.1 persons per vehicle, the "worst case" would be the addition of 550 vehicles to Westbrook traffic during the peak hours of the period of maximum construction activity. Because the commuting hours of construction workers are likely to coincide with those of other workers in the area, these vehicles will exacerbate existing peak traffic hour congestion in the area. In addition, the vehicles could cause congestion in areas where it is not now experienced.

As with many of the other transportation-related impacts, it is difficult to predict the exact magnitude and location of resulting traffic problems without knowing which routes the vehicles will use to travel to the plant site. Exact travel patterns of the workers cannot, of course, be determined until particular contractors are selected for the construction work.

A recent report (Joint Venture 1978) identifies eight intersections in Westbrook with design deficiencies. Only two of those (Warren Avenue and Cumberland Street, Wayside Drive and Spring Street) have capacity deficiencies which result in moderate congestion under existing traffic conditions. Both of the capacity-deficient intersections would be likely to carry a number of power plant construction workers, and, thus, existing congestion will be exacerbated. Other areas that could experience congestion from construction workers' vehicles include any intersections through which substantial proportions of that traffic pass. A typical signalized intersection approach has a physical capacity of less than five hundred vehicles per hour per lane. Thus, the 550 vehicles, if concentrated at any intersections in the area, could cause substantial congestion.

The most important alternative that could be used to reduce traffic impacts of construction workers would be to stagger work hours to avoid existing traffic peaks. Effective use of such a strategy could reduce or eliminate potential traffic problems.

3.6 IMPACTS OF ELECTRIC POWER TRANSMISSION

The proposed wood-fired power plant will generate 18.16 megawatts of electric power for sale to the public grid (Finn 1979a). This power will be transmitted from the S.D. Warren Company along an existing right-of-way to connect with Central Maine Power Company's grid system at the existing meter site two thousand feet from the proposed power plant (Clark 1979). No new right-of-way will be required and no changes will have to be made in Central Maine Power Company's transmission system (Clark 1979). However, the power line traversing the distance between the power plant and the meter site will be replaced. Currently, a single-pole line with two wires brings power from the grid to S.D. Warren. A new single-pole line with two wires will be constructed and the existing wire and poles will be removed. Both existing and proposed power lines are rated at 345 kilovolts. No change in the associated electromagnetic field will result (Clark 1979).

3.6.1 Impacts on Terrestrial Ecosystems

The proposed transmission line will be strung along an existing 100-foot right-of-way, much of which traverses land used by industry. No vegetation will be removed for the construction of the power line; however, currently existing vegetation control activities will continue. The use of heavy construction equipment and trucks may result in soil compaction. In addition, some soil disturbance will occur as holes are dug for the new transmission poles. The right-of-way generally has a very moderate slope and significant erosion of soil is not expected.

Where grass and shrubs exist along the right-of-way, disturbance due to the construction of the new line will be temporary and recovery to its current state is predicted within one or two growing seasons. Rodent and bird populations of the power line right-of-way could experience disruptions of similar duration. No rare or endangered species are known to exist on this site, which has vegetation characteristic of rights-of-way and similarly disturbed areas of coastal New England.

3.6.2 Impacts on Water Quality

The existing transmission line right-of-way does not traverse streams or ponds and is essentially flat. Soil erosion and sedimentation of surface runoff from the placement or removal of poles is expected to be intercepted by vegetation on surrounding land or collected in the S.D. Warren water treatment system. Consequently, no adverse impacts on water quality are anticipated.

3.6.3 Impacts on Land Use

No new or extended right-of-way will be constructed for this project and therefore no additional impacts on land use are expected to occur.

3.6.4 Socioeconomic Impacts

Information concerning the expenditures and employment resulting from the placement of a new 2,000-foot line from S.D. Warren to the Central Maine Power Company meter site is not available at this time. The project, however, will be of short duration and will not stimulate any noticeable changes in the regional economy. Public concern over noise and biological hazards caused by power lines does exist. However, no change in electromagnetic field or noise level is expected to occur with the proposed action; therefore the public will not be subject to any increased hazard.

3.7 STEAM CUSTOMER IMPACTS

S.D. Warren Company produces 172,000 tons of high quality paper per year and employs 2,176 persons at the mill for a gross payroll of about $32,000,000 per year. The new wood-fired steam-electric plant will neither alter pulp and paper production nor significantly change employment at the mill.

The manufacturing process will be essentially unchanged by the addition of the boiler; the steam produced by the biomass boiler will be used to replace that now produced by three oil-fired boilers and a bark-fired boiler, which together produce an average of 342,000 pounds of steam per hour. The new boiler will also produce approximately eighteen megawatts of electricity for sale to the utility grid (see Chapter 1).

S.D. Warren Company's steam plant may be replaced in the near future. The new biomass boiler will enable S.D. Warren Co. to continue to produce pulp and paper at their Westbrook plant while assuming some risk in experimenting with a desirable but unproven fuel source. The plant consequently will continue to provide employment at the present level and to contribute to the regional economy at the current level of $4.5 million per year in local purchases (Rolfe 1979) plus $3 million per year in local taxes (Finn 1979a).

Accounting for the boilers and electric-generating equipment that S.D. Warren Co. will retire as a result of this project and allowing for the sale of electricity to the local grid, the project will result in a savings of an estimated 765,900 barrels per year of fuel oil (Finn 1979a).

3.8 SUMMARY OF ADVERSE ENVIRONMENTAL IMPACTS

Construction

The most significant environmental impacts resulting from the construction of the proposed wood-fired power plant will be traffic congestion and noise. At the peak of construction activity, as many as 550 vehicles transporting workers may arrive at the site daily. If construction work hours substantially coincide with S.D. Warren Co. shift hours (a likely event), significant traffic congestion could occur at signalized intersections throughout Westbrook.

Construction will substantially increase ambient noise levels in the area surrounding the S.D. Warren Company mill, particularly in areas immediately adjacent to the construction site. Sound levels will be raised by as much as thirteen decibels in nearby residential and hospital areas. Construction sound levels will rarely exceed levels causing physiological harm, but may impede normal outdoor speech communication and cause hearing loss to persons spending extended periods on the construction site without hearing protectors. Construction is not expected to cause other significant adverse environmental impacts.

Operation

The most significant environmental impacts resulting from operation of the proposed wood-fired power plant will result from changes in air pollutant emissions and solid waste disposal. The best available data on emissions from wood-fired boilers indicates that nitrogen oxide emissions and carbon monoxide emissions will increase as a result of replacing existing S.D. Warren Company oil and bark-fired boilers with the proposed wood-fired unit. Nitrogen oxide emissions may increase between 660 and 1,030 tons per year. Carbon monoxide emissions may increase between 180 and 450 tons per year. Under worst case conditions, one-hour ground level ambient concentrations of nitrogen oxides may increase by up to 70 micrograms per cubic meter 0.8 kilometers from the plant. Similarly, one-hour concentrations of carbon monoxide may increase by 10 to 20 micrograms per cubic meter 0.8 kilometers from the plant.

The plant will use an additional 1,223 gallons per minute of

Presumpscot River water and will discharge an extra 232 gallons per minute to the river with resultant small changes in water quality. The proposed wood-fired power plant will produce approximately 80 tons of ash per day. This ash will contain small concentrations of toxic metals. Properly landfilled, these substances should pose no hazard to drinking water or aquatic environments. Were leachate from the landfill to contaminate water supplies, damage to the public health could occur.

Harvesting

The environmental impacts of harvesting are highly management dependent. Properly conducted, harvesting should have few impacts. Many harvest operations do significantly affect the forest environment, however. Soil compaction, erosion, and changes in organic matter content can occur as a result of harvesting. Soil compaction is normally a temporary phenomenon. The most severe erosion incidents typically occur as a result of inadequate use of erosion control mechanisms in the design of forest roads. Erosion results in the loss of critical topsoil, causes gullying, and may reduce the long-term productivity of the forest.

Soil erosion almost inevitably increases sediment loads in streams or ponds. Other harvest impacts on water quality occur as a result of increased nutrient leaching and the removal of trees which shade streams. Both increased nutrient leaching and water temperature may accelerate rates of eutrophication of harvest region water.

Harvest activity may affect the nutrient cycles of forest ecosystems in a variety of ways, systems whose effects are only partially understood. The nutrient impacts of intensive harvesting systems (such as clearcutting) with whole-tree removal may be severe if short harvest rotations are employed. The impacts of less intensive harvest systems would be less severe, although the exact nature of harvest impacts on nutrient cycles is not well understood.

Harvesting may adversely affect wildlife populations if critical stands, such as those providing winter deer yards are moved. Similarly, some species of birds, such as woodpeckers, are

dependent on rotten trees for food and habitat. Failure to leave some such trees would be detrimental to these populations.

Finally, harvesting may affect other uses of the forest such as recreation, and the harvest of trees to produce materials such as pulp or reconstituted boards.

Transportation

Transportation of wood to the proposed wood-fired power plant will increase the number of large semi-trailer vans using the roads and streets of the fuelwood harvest region and Westbrook. In general, deliveries of wood to the power plant will be dispersed throughout the day and impacts on traffic congestion should not be significant. Some increase in traffic noise levels will occur, however, as will relatively small increases in the emission of air pollutants.

3.9 SUMMARY OF BENEFICIAL ENVIRONMENTAL EFFECTS

Construction

The primary benefit of the construction period will be a small but significant boost to the Greater Portland area regional economy. Construction of the proposed wood-fired power plant will create an average of approximately 510 direct jobs and an additional 490 indirect jobs for the duration of the two-year construction period. Direct local income accruing from plant construction will total $15.7 million annually which will stimulate about $18.7 million in indirect regional income. Construction of the proposed plant as currently scheduled will follow the completion of two major construction projects in the Greater Portland area and consequently will serve to support rather than to expand the regional economy.

Operation

The replacement of S.D. Warren Company's current boiler system with the proposed wood-fired power plant will result in a decline in air emissions of total suspended particulates and sulfur dioxide. Emissions of particulates will be reduced by between 240 and 380 tons per year. Emissions of sulfur dioxide will be reduced by between 4,840 and 7,120 tons per year.

Harvesting

Harvesting for the proposed wood-fired power plant will have both positive and adverse environmental affects. Harvesting will create approximately 115 direct jobs and stimulate about 135 indirect positions as a result of the economic multiplier effect. Direct annual regional income resulting from the project will total approximately $3.5 million while indirect income will be about $4.3 million. This income will be dispersed throughout the rural portions of the region and will not create adverse boom town effects.

Because the proposed wood-fired power plant can burn wood of any quality, it will create silvicultural opportunities for the improvement of the forest. If sound harvest systems are employed and operations are well-managed, both the economic value of the

residual stand and its aesthetic value could be improved. In addition, harvesting can improve the vigor of aging or overcrowded stands.

When harvesting is applied in a dispersed fashion and creates a patchwork of different habitat types, the diversity and number of wildlife generally increase. This outcome is likely from this project.

Use of Residues

Currently, many millwood residues from the wood products industry are disposed of in landfills or incinerated in open bark burners. The proposed project will provide an alternative for the disposal of these residues. Combustion of the residues in the proposed wood-fired power plant will reduce the need for landfill space and substantially reduce the emission of particulate matter into the air.

3.10 POTENTIAL CUMULATIVE LONG-TERM ENVIRONMENTAL EFFECTS

Approximately 700,000 green tons of wood per year will be committed to the operation of the proposed wood-fired steam-electric facility. Some of this wood will be procured through the use of long-term contracts for millwood residues. A larger portion of the wood will be procured from fuelwood harvest operators. The construction and operation of the proposed plant will impede the entry or expansion of other wood-using facilities relying on the fuelwood harvest region for the production of low-quality wood. To the extent that potential manufacturing facilities are displaced by the proposed project, the ability of the wood resource to support the employment of the region may be reduced. Materials production requires a much greater labor force per ton of wood consumed than does energy production. On the other hand, the use of wood to produce industrial process steam for the S.D. Warren Mill in Westbrook will help to secure the economic and environmental viability of that facility. The S.D. Warren Company employs approximately 2,175 persons and has a gross annual payroll of about $32 million. Hence, the construction of an environmentally sound boiler system in conjunction with the S.D. Warren Company will help to secure employment critical to the Greater Portland area.

The harvest of about 480,000 green tons of wood per year with whole-tree methods could impact the nutrient cycles and long-term productivity of the harvest forest lands. The degree and nature of these impacts will depend on the intensity and size of harvest operations, the total amount of material removed per acre, and the period of time between harvests. Shorter harvest rotations, more intensive operations, and larger contiguous harvest areas may lead to the long-term depletion of the nutrient capital and organic matter content of forest soils and result in a decline in the capability of the forest to produce timber, fiber, and wildlife. Sound forest management will limit this potential for forest degradation.

The major significant potential long-term impact of operating the proposed wood-fired power plant will result from the disposal

of ash from the boiler. Over the expected thirty-year life of the facility, approximately 816,000 tons of wood ash will be generated. The ash from burning wood and oil will contain small quantities of toxic substances including zinc, copper, nickel, chromium, and vanadium. Properly disposed of, these substances do not represent a hazard to water supplies. Should they contaminate surface or ground waters, however, they may accumulate in living organisms within the ecosystem. Water discharged to the Presumpscot River from the ash ponds will also contain small quantities of these same toxic substances, which may accumulate in living organisms in the river.

3.11 PROJECT'S CONTRIBUTION TO NATIONAL ENERGY GOALS

On October 15, 1978, Congress passed into law the National Energy Act, composed of five bills:

- the National Energy Conservation Policy Act,
- the Powerplant and Industrial Fuel Use Act of 1978,
- the Public Utilities Regulatory Policies Act of 1978
- the Natural Gas Policy Act of 1978, and
- the Energy Tax Act of 1978.

The purpose of the Act, as expressed by U.S. Department of Energy Secretary Schlesinger, "is to put into place a policy framework for decreasing oil imports by:

- replacing oil and gas with abundant domestic fuels in industry and electric utilities,
- reducing energy demand through improved efficiency,
- increasing production of conventional sources of domestic energy through more rational pricing policies, and
- building a base for the development of solar and renewable energy sources."

The proposed wood-fired steam-electric facility contributes directly and materially to three of the four goals. Mill residues and harvested fuelwood burned in the new boiler will replace 765,900 barrels of oil currently used for the production of steam and electricity (Finn 1979a). The use of a cogenerating boiler in the wood-fired plant will reduce emissions of waste heat and increase efficiency of the facility. The plant will provide a significant demonstration of appropriate technologies and environmental standards for the development of wood as a sustainable, renewable energy source for industry in the Northeast.

Several specific provisions within the Act indicate the degree to which the facility reflects Congress's objectives. The Powerplant and Industrial Fuel Use Act provides for prohibition of new gas- and oil-fired boilers. Unless exemptions are granted by the Department of Energy, new oil- or natural gas-fired electrical generation facilities with outputs greater than one hundred million Btu per hour may not be constructed.

The Public Utility REgulatory Policies Act encourages cogeneration. The Federal Energy Regulatory Commission is now required

to issue rules favoring cogeneration facilities and requiring utilities to buy or sell power from a qualifing cogenerating facility or a qualifying small power production facility, with rated capacities not exceeding eighty megawatts at just and reasonable rates.

The Energy Tax Act provides for changes in the investment tax credit. An additional 10 percent tax credit is now available for industrial investments in alternative energy facilities. Tax credits and accelerated depreciation are denied to those investing in new oil and gas boilers.

New England is an appropriate site for this demonstration facility. The region exemplifies the energy problems that called forth the National Energy Plan and also produces an abundant supply of wood. Among other reasons why the region should prove a valuable test for new energy policies are the following:

- New England's overall energy costs rose nearly 130 percent between 1970 and 1976. They are now about 25 percent greater than the national average (NECC 1978).

- Coal, the major alternative to oil as a boiler fuel, had a 1976 delivered cost per ton 85 percent greater in New England than in the nation as a whole (NECC 1978). Its use in New England is further hampered by stringent environmental standards.

- Eighty percent of all energy in New England comes from oil, versus about half for the whole country (NECC 1978).

- In 1976, 80 percent of New England's oil was foreign-based, versus 40 percent for the national average (NECC 1978).

- Eighty percent of New England's land is covered by forests, versus 33 percent for the nation as a whole (USFS 1974).

3.12 REFERENCES

Aber, Botkin & Melillo 1978 — Aber, J.D.; Botkin, D.B.; and Melillo, J.M. "Predicting the Effects of Different Harvesting Regimes on Productivity and Yield in Northern Hardwoods," unpublished manuscript, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA (1978)

Adamus & Clough 1976 — Adamus, P.R., and Clough, G.C. A Preliminary Listing of Noteworthy Natural Features in Maine, Center for Natural Areas, South Gardiner, ME (June 1976).

Adler, Blakey & Meyer 1978 — Adler, Thomas; Blakey, Margaret; and Meyer, Timothy. The Direct and Indirect Costs of Transporting Wood Chips to Supply a Wood-fired Power Plant, DSD #103-1, Resource Policy Center, Thayer School of Engineering, Hanover, NH (1978).

Androscoggin 1977 — Androscoggin Valley Regional Planning Commission. Lewiston-Auburn Little Androscoggin River Section 208 Water Quality Program Management Plan and Environmental Impact Assessment, draft AVRPC, Auburn, ME (1977).

Art et al. 1974 — Art, H.W.; Bormann, F.H.; Voigt, G.K.; and Woodwell, G.M. "Barrier Island Forest Ecosystem: The Role of Meteorological Nutrient Inputs," Science, vol. 184 (1974).

Auberton & Patric 1974 — Auberton, G.M., and Patric, J.H. "Water Quality After Clearcutting a Small Watershed in West Virginia," Journal of Environmental Quality 3 (3) (July-September 1974).

Babcock & Wilcox 1972 — Babcock & Wilcox Company, Steam, Its Generation and Use, Babcock & Wilcox Co., New York (1972).

Baerwald 1965 — Baerwald, John E., ed. Highway Capacity Manual, Third Edition (Washington: Institute of Traffic Engineers, 1965).

Beaton & Bourget 1968	Beaton, J.L., and Bourget, L. "Can Noise Radiation from Highways be Reduced by Design?", Highway Research Record No. 232, Highway Research Board, Washington, DC (1968).
Bethlahmy 1972	Bethlahmy, Nedarim. Comments on "Effects of Forest Clearfelling on the Storm Hydrograph," Water Resource Research 8 (1) (1972).
Bittner 1978	Bittner, Burt A., Project Engineer, S.D. Warren Company, Westbrook, ME. Telephone conversation (September 28, 1978).
Bormann et al. 1974	Bormann, F.H.; Likens, G.E.; Siccama, T.G.; Pierce, R.S.; and Eaton, J.S. "The Export of Nutrients and Recovery of Stable Conditions Following Deforestation at Hubbard Brook," Ecological Monographs, vol. 44 (1974).
Bourassa 1978	Bourassa, G., Director of Utilization and Marketing Division, Bureau 4, Maine Department of Conservation, Augusta, ME. Meeting (August 26, 1978).
Boyle, Phillips & Ek 1973	Boyle, J.R.; Phillips, J.J.; and Ek, A.R. "Whole Tree Harvesting: Nutrient Budget Evaluation," Journal of Forestry, vol. 71 (1973).
Brady 1974	Brady, N.C. The Nature and Properties of Soils, 8th Edition (New York: Macmillan Publishing Co., Inc. 1974).
Bragdon 1970	See Section 2.4.
Brush 1976	Brush, Robert O. "Spaces Within the Woods: Managing Forests for Visual Enjoyment," Journal of Forestry 74 (11) (November 1976).

Budney 1977 — Budney, Laurence J. Guidelines for Air Quality Maintenance, Planning, and Analysis, Vol. 10 (Revised): Procedures for Evaluating Air Quality Impact of New Stationary Sources, EPA-450/4-77-001, U.S. Environmental Protection Agency, Research Triangle Park, NC (1977).

Carpenter et al. 1977 — Carpenter, P.; Jones, W.J.; Raskin, S; and Tabors, R. "Conservation," Appendix B of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977).

CCC 1978 — Commerce Clearing House, Inc. State Tax Handbook, CCC, Chicago, IL (1978).

Census 1976a — U.S. Department of Commerce, Bureau of the Census. County Business Patterns in Maine, USDC, Washington, DC (1976).

Census 1976b — See Census 1976a in Section 2.4.

CFR 1977 — Code of Federal Regulations, Title 40, part 60. (Amended July 1977).

Chandler 1978 — Chandler, John, Bureau of Air Quality Control, Maine Department of Environmental Protection, Augusta, ME. Meeting (December 6, 1978).

Clark 1979 — Clark, Leonard, Senior Designer, Rust Engineering Company, Birmingham, AL. Telephone conversation (March 9, 1979).

Cleaves 1978 — Cleaves, Robert E. The Maine Location for Your Plant, Area Development Council of Maine, Augusta, ME (1978).

Clifford 1978 — Clifford, N., Construction Manager, Portland Water District, Portland, ME. Telephone conversation (August 9, 1978).

Corbett, Lynch & Sopper 1978 — Corbett, E.S.; Lunch, J.A.; and Sopper, W.E. "Timber Harvesting Practices and Water Quality in the Eastern United States," Journal of Forestry (August 1978).

Corvetti 1978 — See Section 2.4.

Cover 1979 — Cover, John, Staff Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (January 30, 1979).

Dashnaw 1978 — Dashnaw, Henry N., Owner, Dashnaw Lumber, Peru, NY. Telephone conversation (November 30, 1978).

Day 1979 — Day, Russell, Public Affairs Manager, S.D. Warren Company, Westbrook, ME. Telephone conversation (February 22, 1979).

Dellinger 1978 — Dellinger, Robert, Wood Fiber Division, U.S. Environmental Protection Agency, Washington, DC. Telephone conversation (November 9, 1978).

Donahue 1979 — Donahue, Michael P., Maine Department of Manpower Affairs, Augusta, ME. Telephone conversation (March 21, 1979).

Dutton 1978 — Dutton, Robert M., Administrative Assistant, Road Maintenance Division, New Hampshire Department of Public Works and Highways, Concord, NH . Meeting (August 17, 1978).

Dyer 1979 — Dyer, R., Botanist, U.S. Fish and Wildlife Service, Newton Corners, MA. Telephone conversation (April 2, 1979).

Dvorak et al. 1977 — Dvorak, A.J., et al. The Environmental Effects of Using Coal for Generating Electricity, Argonne National Laboratory, Argonne, IL (1977).

Eastman 1977 — Eastman, L.M. "Small Whorled Pogonia," Isotaria medeoloides (Pursh) Raf., in Maine, and its Relevance to the Critical Areas Program," Maine Critical Areas Program, State Planning Office, Augusta, ME (1977).

Eaton, Likens & Bormann 1973 — Eaton, J.S.; Likens, G.E.; and Bormann, F.H. "Throughfall and Stemflow Chemistry in a Northern Hardwood Forest," Journal of Ecology, vol. 61 (1973).

Eldred 1971 — Eldred, K.M. Community Noise, NTID 300.3, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, DC (1971).

EPA 1973 — Committee on Water Quality Criteria. Water Quality Criteria 1972, Ecological Research Series, EPA-R3-73-033, Environmental Studies Board, National Academy of Sciences, National Academy of Engineering, U.S. Environmental Protection Agency, Washington, DC (1973).

EPA 1974 — U.S. Environmental Protection Agency, Office of Noise Abatement and Control. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, Report No. 550/9-74-004, EPA, Washington, DC (1974).

EPA 1975 — Water Division, EPA Region X. "Logging Roads and Protection of Water Quality," EPA 910/9-75/007, U.S. Environmental Protection Agency, Washington, DC (March 1975).

EPA 1976 — U.S. Environmental Protection Agency. Compilation of Air Pollution Emission Factors, 2nd ed., AP-42, EPA, Research Triangle Park, NC (1976).

Ferguson & Kingsley 1972 — See Section 2.4.

Finn 1978 — Finn, William D., Project Engineer, Rust Engineering Company, Birmingham, AL. Letter (November 14, 1978).

Finn 1979a — Finn, William D., Project Engineer, Rust Engineering Company, Birmingham, AL. Letter (February 2, 1979).

Finn 1979b — Finn, William D., Project Engineer, Rust Engineering Company, Birmingham, AL. Letter (February 8, 1979).

Finn 1979c — Finn, William D., Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (March 2, 1979).

Foster 1974 — Foster Associates. Energy Prices, 1960-1973 (Cambridge, MA: Ballinger Publishing Co., 1974).

FR 1978 — Federal Register. vol. 43. page 46246 (October 5, 1978).

FR 1979 — Federal Register, vol. 44, no. 29 (February 9, 1979).

Fryling 1966 — Fryling, G.R., ed. Combustion Engineering (New York: Combustion Engineering, Inc., 1966).

Galloway, Clark & Kerrick 1969 — Galloway, W.J.; Clark, W.E.; and Kerrick, G.S. Highway Noise: Measurement, Simulation, and Mixed Reactions, Report No. 78, National Cooperative Highway Research Program, Highway Research Board, Washington, DC (1969).

Gardner 1978 — Gardner, Rulon B. Cost, Performance, and Esthetic Impacts of an Experimental Forest Road in Montana, Research Paper INT-203, U.S. Department of Agriculture Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT (April 1978).

GCC 1978 — Governor's Commission on Cogeneration. Cogeneration: Its Benefits to New England, Final Report, GCC, Boston, MA (October 1978).

Gibbons & Salo 1973 — Gibbons, D.R., and Salo, E.O. An Annotated Bibliography of the Effects of Logging on Fish of the Western United States and Canada, Technical Report PNW-10, U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR (1973).

Gordon et al. 1973	Gordon, C.G.; Galloway, W.J.; Kugler, B.A.; and Nelson, D.L. Highway Noise: A Design Guide for Highway Engineers, Report No. 117, National Cooperative Highway Research Program, Highway Research Board, Washington, DC (1973).
Gorrill 1969	See Section 2.4
GOCOG 1977	See GPCOG 1977a in Section 2.4.
Gramlich 1979	See Section 2.4.
Granskog & Siegel 1978	Granskog, J.E., and Siegel, W.C. "Legal Distinction Between Employee and Independent Contractor as Applied to Collective Bargaining Activities in Timber Harvesting," Forest Producers Journal 28 (9) (1978).
Griffin 1979a	Griffin, Glenn H., Noise Control Engineer, Rust Engineering Company, Birmingham, AL. Letter (February 5, 1979).
Griffin 1979b	Griffin, Glenn H., Noise Control Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (March 2, 1979).
Hewett 1978	Hewett, Charles. The Availability of Wood for a 50-Mw Wood-Fired Power Plant in Northern Vermont, DSD #114, Resource Policy Center, Thayer School of Engineering, Hanover, NH (1978).
Hickey 1979	Hickey, Harold, Superintendent of Schools, Westbrook, ME. Telephone conversation (March 29, 1979).
Hills 1978	Hills, Bruce, Air Quality Engineer, S.D. Warren Company, Westbrook, ME. Meeting (October 17, 1978).
Hills 1979a	Hills, Bruce, Air Quality Engineer, S.D. Warren Company, Westbrook, ME. Telephone conversation (January 24, 1979).
Hills 1979b	Hills, Bruce, Air Quality Engineer, S.D. Warren Company, Westbrook, ME. Telephone conversation (February 16, 1979).

Hillstrom & Steinhilb 1976 — Hillstrom, W.A., and Steinhilb, Helmuth M. "Mechanized Thinning Shows Promise in Northern Hardwoods," Northern Logger 24 (12) (1976).

Hobbie & Likens 1973 — Hobbie, J.E., and Likens, G.E. "Output of Phosphorus, Dissolved Organic Carbon, and Fine Particulate Carbon from Hubbard Brook Watersheds," Limnology and Oceanography 18 (5) (1973).

Hornbeck 1977 — Hornbeck, J.W. "Nutrients: A Major Consideration in Intensive Forest Management," in Proceedings of the Symposium in Intensive Culture of Northern Forest Types, General Technical Report NE-29, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1977).

Hornbeck 1978 — Hornbeck, J.W., Principal Forest Hydrologist, Forest Science Laboratory, Durham, NH. Telephone conversation (November 28, 1978).

Hornbeck et al. 1975 — Hornbeck, J.W.; Pierce, R.S.; Likens, G.E.; and Martin, C.W. "Moderating the Impact of Contemporary Forest Cutting on Hydrologic and Nutrient Cycles," Proceedings of the Symposium on the Hydrological Characteristics of River Basins, Publication 117, International Association of Hydrological Sciences, Paris, and Science Council of Japan, Tokyo (1975).

Hornbeck & Federer 1975 — Hornbeck, J.W., and Federer, C.A. "Effect of Management Practices on Water Quality and Quantity - Hubbard Brook Experimental Forest, New Hampshire," Municipal Watershed Management Symposium Proceedings, General Technical Report NE-13, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1975).

Hornbeck, Pierce & Federer 1970	Hornbeck, J.W.; Pierce, R.S.; and Federer, C.A. "Streamflow Changes After Forest Clearing in New England," Water Resource Research 6(4) (1970).
Johnson 1974	See Section 2.4.
Joint Venture 1978	The Joint Venture. PACTS Short-Range Plan, Transportation System Management Roadway Element, interim draft report, The Joint Venture: S.G. Assoc., Inc.; Roger Creighton Assoc., Inc.; Hunter-Ballow, Assoc., Portland, ME (1978).
Jorgensen, Wells & Metz 1975	Jorgensen, J.K.; Wells, C.G.; and Metz, L.J. "The Nutrient Cycle: Key to Continuous Forest Production," Journal of Forestry, vol. 73 (1975).
JPR 1979	JPR Associates. Biomass Transport, preliminary draft of report prepared for Rust Engineering Company, JPR Assoc., Stowe, VT (1979).
Kochenderfer 1970	Kochenderfer, J.N. Erosion Control on Logging Roads in the Appalachians, Research Paper NE-158, U.S. Department of Agriculture Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1970).
Kochenderfer & Aubertin 1975	Kochenderfer, J., and Aubertin, G. "Effects of Management Practices on Water Quality and Quantity: Fernow Experimental Forest, W. Virginia," Municipal Watershed Management Symposium Proceedings, General Technical Report NE-13, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1975).
Kugler & Piersol 1973	Kugler, B.A., and Piersol, A.G. Highway Noise: A Field Evaluation of Traffic Noise Reduction Measures, Report No. 144, National Cooperative Highway Research Program, Highway Resource Board, Washington, DC (1973).
Labrecque 1979	See Section 2.4.

Lee & Samuel 1976 — Lee, R., and Samuel, D.E. "Some Thermal and Biological Effects of Forest Cutting in West Virginia," Journal of Environmental Quality 5(4) (October-December 1976).

Likens et al. 1970 — Likens, G.E.; Bormann, F.H.; Johnson, N.H.; Fisher, D.W.; and Pierce, R.S. "Effects of Forest Cutting and Herbicide Treatment on Nutrient Budgets in the Hubbard Brook Watershed-ecosystem," Ecological Monographs, vol. 40 (1970).

Likens et al. 1977 — Likens, G.E.; Bormann, F.H.; Pierce, R.S.; Eaton, J.S.; and Johnson, N.H. Biogeochemistry of a Forested Ecosystem (New York: Springer - Verlag, 1977).

Likens et al. 1978 — Likens, G.E.; Bormann, F.H.; Pierce, R.S.; and Reiners, W.A.; "Recovery of a Deforested Ecosystem," Science, vol. 199 (1978).

Likens & Bormann 1970 — Likens, G.E., and Bormann, F.H. "Chemical Analyses of Plant Tissues from the Hubbard Brook Ecosystem in New Hampshire," Bulletin 79, Yale University School of Forestry, New Haven, CT (1970).

Lull & Reinhart 1967 — Lull, H.W., and Reinhart, K.G. Increasing Water Yield in the Northeast by Management of Forest Watersheds, Research Paper NE-66, U.S. Department of Agriculture Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1975).

Lynch et al. 1975 — Lynch, J.A.; Sopper, W.E.; Corbett, E.S.; and Aurand, D. "Effects of Management Practices on Water Quality and Quantity - Penn State Experimental Watersheds," Municipal Watershed Management Symposium Proceedings, General Technical Report NE-13, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, PA (1975).

Lynch, Corbett & Hutnik 1975 — Lynch, J.A.; Corbett, E.S.; and Hutnik, R.J. Clearcutting in Pennsylvania (State College, PA: Pennsylvania State University Press, 1975).

Lynch, Sopper & Partridge 1972 — Lynch, J.A.; Sopper, W.E.; and Partridge, D.B. "Changes in Streamflow Following Partial Clearcutting on a Forested Watershed" in Watersheds in Transition, S.C. Csallany, T.G., McLaughlin, and W.D. Striffer, eds. (Urbana, IL: American Water Resources Association, 1972).

Maine News 1979 — Maine Environmental News, vol. 5, no. 9, Maine Department of Environmental Protection, Augusta, ME (February 1979).

Manar 1978a — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (August 15, 1978).

Manar 1978b — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (August 11, 1978).

Manar 1978c — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Letter (October 3, 1978).

Manar 1978d — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (December 12, 1978).

Manar 1978e — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (December 15, 1978).

Manar 1979a — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Letter (March 12, 1979).

Manar 1979b — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (March 28, 1979).

Manar 1979c — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Letter (April 11, 1979).

Manar 1979d — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Meeting (May 17, 1979).

MBT 1979 — Maine Bureau of Taxation, Property Tax Division. 1978 Full Value Rates and Ratios - Cumberland County, Maine, MBT, Augusta, ME (1979).

McGirr 1979 — McGirr, Robert, "Chemical Analyses of Wood Ash," Unpublished manuscript, Thayer School of Engineering, Dartmouth College, Hanover NH (1979).

McPherson 1978 — McPherson, John, Construction Manager, Central Maine Power Company, Cousin's Island, ME. Telephone conversation (August 11, 1978).

MDEP 1972 — Maine Department of Environmental Protection. Implementation Plan for Air Quality Control, MDEP, Augusta, ME (1972).

MDEP 1977 — Maine Department of Environmental Protection "Protection and Improvement of Air," Maine Revised Statutes Annotated Title 38, Chapter 4; and Title 29, Chapter 13, (October 1977).

MDEP 1979 — Maine Department of Environmental Protection "State Implementation Plan for Air Quality." Draft Proposed Revision (Jan. 24, 1979).

MDMA 1976 — Maine Department of Manpower Affairs. Occupational Injuries and Illnesses in Maine, MDMA, Augusta, ME (1976).

MDMA 1979 — Maine Department of Manpower Affairs. "1978 Average Unemployment For Selected Labor Market Areas," MDMA, Augusta, ME (February 1979).

MDOT 1974 — Maine Department of Transportation. State of Maine Traffic Flow Map, State of Maine Bureau of Planning and U.S. Department of Transportation, Federal Highway Administration, MDOT, Augusta, ME (1974).

MDOT 1978 — Maine Department of Transportation. "Highway maintenance cost summary," on file at MDOT, Augusta, ME (1978).

Meffert 1978 — Meffert, D.P., Senior Staff Engineer, Rust Engineering Company, Birmingham, AL. Letter (November 7, 1978).

MFS 1977 — Maine Forest Service. Statewide Average Mill Delivered Prices, MFS, Utilization and Marketing Division, Augusta, ME (Fall 1977).

MFS 1978a — Maine Forest Service. Statewide Average Mill Delivered Prices, MFS, Utilization and Marketing Division, Augusta, ME (Spring 1978).

MFS 1978b — Maine Forest Service. Statewide Average Mill Delivered Prices, MFS, Utilization and Marketing Division, Augusta, ME (Fall 1978).

Miller 1979 — Miller, David, Office Manager, S.D. Warren Company, Westbrook, ME. Telephone conversation (March 29, 1979).

Milligan 1977 — Milligan, S. Brown, Project Manager, Rust Engineering Co., Birmingham, AL. Letter (August 23, 1977).

MLURC 1978 — Maine Land Use Regulation Commission. 208 Preliminary Nonpoint Source Assessment Report submitted to Maine Department of Environmental Protection, Augusta, ME (January 1978).

Mondragon 1978 — Mondragon, J.M. Staff Engineer, Rust Engineering Company, Birmingham, AL. Letter (October 13, 1978).

MTB 1977 — Maine Test Borings, Inc. Subsurface Investigation - Chip Storage, report done under contract to S.D. Warren Co., Westbrook, ME (September 1977).

Murphy 1980 — Murphy, J.D. Memorandum: Wood Fired Power Plant Wastewater, Rust Engineering Co., Birmingham, AL (Aug. 27, 1980).

NECC 1978 — New England Congressional Caucus. New England Energy Fact Book, NECC, Washington, DC (April 1978).

News 1978 — Bangor Daily News, Bangor, ME (September 13, 1978).

NHDPW 1978 — New Hampshire Department of Public Works. "Highway maintenance cost summary," on file at NHDPW, Concord, NH (1978).

Nickerson 1979 — Nickerson, Paul, Senior Staff Specialist, U.S. Fish and Wildlife Service, Newton Corner, MA. Telephone conversation (April 2, 1979).

NOAA 1978 — See Section 2.4.

Noyes 1970 — Noyes, John H. Timber Harvesting and Forest Aesthetics, Cooperative Extension Bulletin No. 170, College of Agriculture, University of New Hampshire, Durham, NH (1970).

Noyes 1979 — Noyes, Wesley, Supervisor of Economic Analysis and Reports, N.H. Department of Employment Security, Concord, N.H. Telephone conversation (March 21, 1979).

OSHA 1979 — Occupational Safety and Health Administration. Construction Industry OSHA Safety and Health Standards (29 CFR 1926/1910). OSHA 2207. U.S. Dept. of Labor, Washington, D.C. 1979.

PACTS 1977 — See Section 2.4.

PACTS 1978 — See Section 2.4.

Parks 1978 — Parks, Harold, Mayor, City of Westbrook, ME. Telephone conversation (August 9, 1978).

Patric 1977 — Patric, J.H. "Soil Erosion and its Control in Eastern Woodlands," Northern Logger and Timber Processor (May 1977).

Percival 1978a — Percival, Dave, Owner, Percival Logging Company, Andover, ME. Meeting (June 20, 1978).

Percival 1978b — Percival, Dave, Owner, Percival Logging Company, Andover, ME. Telephone conversation (November 30, 1978).

Pierce et al. 1972 — Pierce, R.C.; Martin, C.W.; Reeves, G.E.; and Bormann, F.H. "Nutrient Loss from Clearcuttings in New Hampshire," in Watersheds in Transition, S.C. Csallany, T.G. McLaughlin, and W.D. Striffer, eds. (Urbana, IL: American Water Resources Association, 1972).

Platt 1978 — Platt's Oil Price Handbook and Oilmanac: 1977 Prices, 54th edition (New York: McGraw-Hill, Inc., 1978).

Ramsdell 1961 — Ramsdell, Earl W. "Air Pollution - Meteorological Data," on file at S.D. Warren Co., Westbrook, ME (February 10, 1961).

Rich 1978a — Rich, J. Phillip. "Identification of Sequential Harvesting Procedure, Preliminary Draft," J.P.R. Associates, Stowe, VT (1978).

Rich 1978b — Rich, J. Phillip, President, J.P.R. Associates, Stowe, VT. Meeting (July 27, 1978).

Rolfe 1979 — Rolfe, Dave, Plant Engineer, S.D. Warren Company, Westbrook, ME. Letter (February 2, 1979).

Roskoski 1977 — Roskoski, J.P. "Nitrogen Fixation in Northern Hardwood Forests," Ph.D thesis, Graduate School of Forestry and Environmental Studies, Yale University, New Haven, CT (1977).

Rust 1979 — The Rust Engineering Company, Birmingham, AL. Meeting (May 15, 1979).

Saeman 1977 — Saeman, Jerome F. "Energy and Materials from the Forest Biomass," paper presented at Institute of Gas Technology Symposium on Clean Fuel from Biomass and Wastes, Forest Products Laboratory, Madison, WI (1977).

S.D. Warren 1978 — S.D. Warren Company. "Application for Wastewater Discharge License," Application No. 164, submitted to Maine Bureau of Water Quality Control, Augusta, ME (1978).

Sewall 1978 — James W. Sewall Company. Preliminary Biomass and Volume Estimates for Westbrook Study Area 1978, James W. Sewall Co., Old Town, ME (1978).

Shettleworth 1978a — See Shettleworth in Section 2.4.

Shettleworth 1978b — Shettleworth, Earle, G., State Historic Preservation Officer, Maine Historic Preservation Commission, Augusta, ME. Letter (October 10, 1978).

Sirois 1978 — Sirois, Abel, Bridge Maintenance Engineer, Maine Department of Transportation, Augusta, ME. Telephone conversation (August 30, 1978).

Smith 1962 — Smith, D.M. The Practice of Silviculture (New York: John Wiley & Sons, 1962).

Spiess 1978a — See Section 2.4.

Spiess 1978b — See Section 2.4.

Sproul & Woodard 1972 — Sproul, O.J., and Woodard, F.E. An Air Pollutant Emissions Inventory and Ambient Air Quality Estimate for Selected Municipalities in Maine: Addenda I and II, submitted to Maine Department of Environmental Protection, Augusta, ME (1972).

Squiers 1979a — Squiers, Thomas, Marine Scientist, Maine Department of Marine Resources, Augusta, ME. Telephone conversation (March 14, 1979).

Squiers 1979b — Squiers, Thomas, Marine Scientist, Maine Department of Marine Resources, Augusta, ME. Telephone conversation (March 22, 1979).

Stearns 1978 — See Section 2.4.

Stone 1973 — Stone, Earl L. The Impact of Timber Harvest on Soils and Water, report of the President's Advisory Panel on Timber and the Environment, Appendix M (Washington: U.S. Government Printing Office, 1973).

Stone 1977 — Stone, R.N. "Are U.S. Wood Supplies Dependable and Adequate?" in Energy Efficiency in Wood Building Construction, proceedings no. P-77-18, Forest Products Research Society, Chicago, IL (1977).

Thron 1978 — Thron, Hap, Permit Program, U.S. Environmental Protection Agency, Washington, DC. Telephone conversation (November 13, 1978).

Times 1978 — New Hampshire Times, Concord, NH (December 6-12, 1978).

TRB 1977 — The Transportation Research Board. Synthesis of Highway Practices 43: Energy Effects, Efficiencies, and Prospect for Various Modes of Transportation, National Cooperative Highway Reasearch Program, TRB, Washington, DC (1977).

TTI 1970 — Texas Transportation Institute. Threshold Noise Levels, Research Report No. 166-1, TTI, Austin, TX (December 1970).

USFS 1974 — See Section 2.4.

USFS 1976 — U.S. Department of Agriculture, Forest Service. The Feasibility of Utilizing Forest Residues for Energy and Chemicals, NTIS-PB 258-630 (Washington: National Technical Information Service, March 1976).

USFWS 1978 — See Section 2.4.

USPHS 1962 — U.S. Public Health Service. Public Health Service Drinking Water Standards (revised), pub. no. 956, U.S. Department of Health, Education, and Welfare, USPHS, Washington, DC (1962).

VanderWerf 1978 — VanderWerf, Pieter. The Regional Employment and Income Effects of 50-Mw Wood-fired Power Plant, DSD #90, Resource Policy Center, Thayer School of Engineering, Hanover, NH (1978).

Verrier 1978 — Verrier, Phillip. "A Look at Timber Harvesting in New Hampshire," Northern Logger and Timber Processor 26(11) (1978).

Webb 1973 — Webb, W.L. "Timber and Wildlife," Appendix N of Report of the Presidents's Advisory Panel on Timber and the Environment, Executive Office, Washington, DC (1973).

Weetman & Webber 1972 — Weetman, G.F., and Webber, B. "The Influence of Wood Harvesting on the Nutrient Status of Two Spruce Stands," Canadian Journal of Forest Resources, vol. 4 (1972).

Westbrook 1973 — City of Westbrook. Zoning Ordinance, as amended, Westbrook City Hall, Westbrook, ME (1973).

White 1974 — White, E.H. "Whole Tree Harvesting Depletes Soil Nutrients," Canadian Journal of Forest Resources, vol. 4 (1974).

Whittaker et al. 1974 — Whittaker, R.H.; Bormann, F.H.; Likens, G.E.; and Siccama, T.G. "The Hubbard Brook Ecosystem Study: Forest Biomass and Production," Ecological Monographs, vol. 44 (1974).

Wilde 1958 — Wilde, S.A. Forest Soils (New York: Ronald Press Co., 1958).

Zasada 1975 — Zasada, Z.A. "Timber Harvesting Effect on Forest and Silvicultural Practices," Proceedings of the Intensive Forest Management Conference, Report 22, College of Forestry, University of Minnesota, St. Paul, MN (1975).

CHAPTER FOUR: RELATIONSHIP TO OTHER GOVERNMENT ACTIVITIES

4.1 FEDERAL, STATE, AND LOCAL PLANS AND PROJECTS

4.1.1 Federal Plans

The National Energy Plan

The proposed steam-electric, wood-fired facility actively supports many of the objectives set forth in The National Energy Plan, published by the U.S. Executive Office of Energy Policy and Planning in April of 1977 and currently under revision. One of the three overriding objectives of the plan is expansion of the use of "renewable and essentially inexhaustible sources of energy." Included in this category are forestry residues, or "biomass," the fuel for the proposed plant. The plan also emphasizes energy efficiency and conservation through the use of such technologies as cogeneration, the simultaneous production of industrial process steam and electricity (EOP 1977). The proposed facility will cogenerate process steam for use in the S.D. Warren Company's paper-making operation and electricity for both S.D. Warren Co. and public consumption.

The National Energy Plan stresses the importance of a federal research, development, and demonstration program to promote the use of new energy sources (EOP 1977). Construction of the wood-fired facility will increase knowledge of and promote development of biomass energy technologies. Facility operation will demonstrate the feasibility of industrial biomass use in New England.

Standards for Air and Water Quality

The Federal Primary Air Quality Standard, set forth in the Clean Air Act (as amended August 7, 1977), establishes maximum allowable atmospheric air pollutant concentrations for the nation. If any area of any state fails to comply with the Standards, the state must develop a control strategy to demonstrate attainment and maintenance of the Standards by December 31, 1982. In Maine, these strategies are incorporated in the Department of Environmental Protection's State Implementation Plan for Air Quality.

The Portland Air Quality Control Region is not in compliance with the federal ozone standard. The Implementation Plan's ozone

control strategy states that new air pollution sources that may emit more than one hundred tons per year of hydrocarbons are subject to more stringent federal and state review processes (MDEP 1979), as hydrocarbons react in the atmosphere to form ozone. The proposed plant is expected to emit seventy tons per year of hydrocarbons. If the plant cannot meet the standard, however, the S.D. Warren Company must reduce hydrocarbon emissions from other mill processes, so that the net hydrocarbon increase does not exceed one hundred tons per year (see Appendix B).

The Federal Water Pollution Control Act Amendments of 1972 seek "to restore and maintain the chemical integrity of the Nation's waters." Section 208 of the act requires each state to develop Water Quality Management Plans identifying the state's nonpoint sources of pollution and appropriate ways to control them. Section 303(e) of the Act requires each state to develop River Basin Water Quality Management Plans identifying the state's point sources of pollution and appropriate ways to control them.

The 208 program addresses the problem of erosion and stream sedimentation caused by timber harvesting activities (see Sections 3.3.1 and 3.3.2). The program plans suggest harvesting management practices to control stream pollution. These management practices include logging during frozen or dry weather conditions, using filterstrips between exposed soil and water bodies, building bridges over or culverts in flowing streams, creating cross drainage for truck and skid roads, mulching and using water bars or dips on truck and skid roads after logging, and removing slash from streams (Goodhue 1977). Section 208 plans also identify harvesting management enforcement programs. Suggested programs include required harvesting permits, harvest acreage limitations, and harvesting operation inspection (NHWSPCC 1978). To date, programs specified by the 208 planning process in the fuelwood harvest region have not been implemented by the legislatures of Maine or New Hampshire. State legislation that does affect harvesting is discussed in Section 4.1.2.

The Presumpscot River Basin-Cumberland County Tidewater Water Quality Management Plan (303 plan) identifies the Presumpscot

River below downtown Westbrook and S.D. Warren as a problem zone. Although prepared prior to completion of the Westbrook and S.D. Warren waste treatment facilities, the Plan identifies those pollution problems that should persist after completion of the facilities and makes management recommendations to S.D. Warren Co. with regard to stream volume. Since plan publication, the S.D. Warren Company has agreed to the recommendations. By law, the proposed project will not be allowed to contradict these management policies (MDEP 1979).

Forest Management

The Guide for Managing the National Forests in New England forms the first phase of the U.S. Forest Service's planning procedure for the National Forests. The Guide outlines the broad policies and objectives to be followed in the management of the natural resources of New England's National Forests, including the White Mountain National Forest of Maine and New Hampshire (USFS 1973). The eastern portion of the White Mountain National Forest is included in the fuelwood harvest region for the proposed project.

Two objectives of the Guide, which the proposed project directly supports, are stimulation of the forest resource market and efficient utilization of wood in harvesting and processing (USFS 1973). The project will bolster the wood chip market and increase utilization of both mill and forest residues.

Fuelwood harvesting in the White Mountain National Forest must be conducted so as to serve other Guide objectives. These objectives, which call for protection of the forest environment and resources, include: 1) protection of rare and endangered species; 2) maintenance of a balance of indigenous species; 3) protection of areas of significant geological, historical, scientific, and vegetative interest; and 4) maintenance of minimum levels of air, water, noise, and visual pollution (USFS 1973).

National forest lands are classified according to their suitability to meet various resource use combinations and according to those management practices which best promote each of these combinations (USFS 1973). Four management classifications

exist. The White Mountain National Forest Plan, the second phase of the National Forest planning process, refines the policies set forth in the Guide and defines the management classifications in a manner consistent with the characteristics of that geographic area. Most of that portion of the National Forest that overlaps with the fuelwood harvest region is in Management Area I. Here the primary resource use objectives include maintenance of a healthy, productive forest cover to provide high quality timber products. Management Areas II and III, which occupy small areas within the fuelwood harvest region, de-emphasize timber production and emphasize recreational resource use and aesthetic values. No wilderness areas are located in the proposed project's fuelwood harvest region.

RARE II, the U.S. Forest Service's Roadless Area Review and Evaluation, is reviewing those areas of the U.S. National Forest System currently classified as "roadless areas" for potential inclusion in the National Wilderness Preservation System. Although two White Mountain National Forest Roadless areas -- Kearsarge and Sandwich Range -- are included in the fuelwood harvest region, neither is likely to be chosen for wilderness area designation (USFS 1978).

The Cooperative Forest Management program, funded by the U.S. Forest Service and administered through the state forestry departments, provides funds for service foresters. These foresters provide management assistance to private, nonindustrial forest landowners. The Cooperative Extension Service, supported by both the Forest Service and the state forestry departments, funds foresters to provide educational services to private forest landowners. The Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture subsidizes small private landowners for timber stand improvement, fire-road construction, and tree planting. Subsidies are provided through two programs: the Forestry Incentives Program and the Agricultural Conservation Program (Gooley 1979). Growth in fuelwood demand could increase demand for the services provided through the above programs. Conversely,

the services themselves could heighten private forest landowners' awareness of the fuelwood market and could stimulate supply.

The Westbrook Area

Within the city of Westbrook, the U.S. Environmental Protection Agency has provided funds for construction of the Westbrook Waste Treatment Plant, owned and operated by the Portland Water District. The treatment plant is located near the Presumpscot River, just downstream of the S.D. Warren industrial complex. The plant has improved and should continue to improve the water quality of the lower Presumpscot River. Water effluent from the proposed plant should not hinder this improvement.

The U.S. Department of Housing and Urban Development has provided funds, through the Community Development Block Grant Program, for completion of the downtown Westbrook urban renewal project (see Section 2.3.3) and for two neighborhood conservation projects. One conservation project is located in the residential area between the Westbrook Arterial and South Main Street, southeast of S.D. Warren. The second project is located along Brown Street, a residential street parallel to and west of the Presumpscot River, south of the S.D. Warren plant (Eyerman 1979). These projects will up-grade development in areas south of and near to the proposed plant site. Construction and operation of the wood-fired facility should not interfere with the success of these projects.

4.1.2 State Plans

Maine's Comprehensive Energy Plan (MOER 1976), prepared by the Office of Energy Resources, does not foresee major shifts in fuel preferences in Maine in the next decade. The Plan estimates that, although the use of wood to produce energy has been increasing and wood is Maine's most abundant native energy source, wood will not furnish much more than 5 percent of the state's total energy requirements by 1985. Most consumption of wood for energy in Maine is expected to be direct burning for space heating; however, wood may also be used to generate electricity.

Many of the Energy Plan's action proposals encourage fuelwood use and recommend that its potential be studied. Action proposals include: 1) provision of information on use of native energy sources; 2) encouragement of the burning of waste wood to produce industrial steam and electricity; 3) evaluation of fuelwood availability in the state; 4) evaluation of the environmental impacts of increased fuelwood use; and 5) development of programs to help cooperation between fuelwood buyers and sellers.

More specifically, the Plan recommends that consideration be given to either allowing a higher rate of return, or exempting entirely from public utility status, an experimental wood-fired (maximum of sixty megawatts) generating station whose electricity would be distributed through an existing utility (MOER 1976). The wood-fired facility described in this document could serve as such an experimental station. Total capacity of the proposed plant will be the equivalent of fifty megawatts; 18.16 megawatts of electicity will be distributed through the Central Maine Power Company distribution system.

The Site Location of Development Act (Maine Revised Statutes Annotated, Title 38, 481-489) maintains that the economic and social well-being of the citizens of Maine depends on the location of industrial development with respect to the natural environment. To ensure that development will not adversely affect the environment, the Act requires that all industrial developments occupying areas in excess of twenty acres and all industrial structures occupying ground areas in excess of sixty thousand square feet receive approval by the State Board of Environmental Protection. The Board will approve a proposed development if the developer is able to demonstrate that the development will not adversely affect the existing uses, the scenic character, or the natural resources of the land.

Although the proposed wood-fired facility will occupy less than twenty acres of land, the five facility structures will occupy a total of approximately 415,000 square feet. The Maine Board of Environmental Protection must therefore review the project. In addition, because the complex includes a permanently

installed power generating facility with a capacity greater than one thousand kilowatts, the development must also be approved by the Maine Public Utilities Commission.

Maine's Comprehensive Outdoor Recreation Plan identifies the supply of, demand for, and deficiencies in outdoor recreation areas and facilities throughout the state, and recommends ways to alleviate the deficiencies in order to maintain a balanced recreational program (MBPR 1977). Protection of environmental and aesthetic quality is central to the enjoyment and appeal of such activities as camping, hiking, boating, and skiing. Other recreational activities, such as fishing and hunting, depend on environmental quality for preservation of fish and wildlife habitats. If sound forest management practices are employed, adverse impacts on environmental quality will be minor and generally short-lived.

The Mandatory Shoreland Zoning and Subdivision Control Act (Maine Revised Statutes Annotated, Title 12, 4811-4814) regulates land use on all "land within 250 feet of the normal high water mark of any pond, river, or salt water body." The Act establishes minimum performance standards for these lands, for the purpose of preserving environmental and aesthetic qualities, protecting vegetation and wildlife habitats, and guarding against flood hazards. The Act establishes three land use districts, each subject to its own set of standards: Resource Protection, Limited Recreational/Residential, and General Development. Timber harvesting and road construction are permitted in the Limited Recreational/Residential and General Development Districts. A permit is required from the local code enforcement office or planning board before harvesting or road construction can take place in a Resource Protection District.

Under the Act, when timber harvesting takes place within fifty feet of the shoreline, no more than thirty out of every one hundred feet of shoreland can be cleared. Within 250 feet of the shoreline, no more than 40 percent of the volume of trees may be removed in any ten-year period. Harvesting must leave well-distributed tree stands, with no openings larger than 7,500 square

feet in the forest canopy. The Act also states that roads and skid trails must be constructed to minimize soil erosion.

The Roadside Cutting Law (Maine Revised Statutes Annotated, Title 12, 519) prohibits the cutting of trees, with the exception of dead or dying trees, within one hundred feet from the edge of a roadway. Selective cutting is allowed, however, provided at least 50 percent of the volume of trees is retained in a well-distributed stand. State forester approval must be obtained if more than 50 percent of the volume is to be cut.

4.1.3 Land Use Plans in the Plant Site Region

Greater Portland Metropolitan Area

The Greater Portland Council of Governments (GPCOG) is the regional planning and management agency whose jurisdiction includes all of the Greater Portland metropolitan region and most of Cumberland County, Maine. In February of 1978, GPCOG published the Regional Development Framework, a final policy statement of the agency's six-part Regional Land Use Plan. The document outlines those goals and policies that should serve to guide all forms of development within Greater Portland (GPCOG 1978).

The proposed biomass facility does not conflict with any of the Framework's policies, but instead strongly promotes many of them. For example, the document states that Greater Portland must 1) reduce its dependence on imported energy resources, and 2) improve its market for natural resource industry products. A wood-fueled power plant directly supports both of these objectives by 1) replacing fossil fuel energy with energy derived from a local renewable resource, and 2) stimulating the market for wood chips.

The Greater Portland Overall Economic Development Program (OEDP) Committee consists of one representative from each of the thirteen municipalities comprising the Greater Portland OEDP area and representatives from business, finance, labor, utilities, education, employment, and low-income organizations. In March of 1977 the committee released its Greater Portland Overall Economic

Development Program. This document, like the Regional Development Framework, outlines goals that should be pursued in the course of economic development. Once again, utilization of the area's natural resources is stressed, as are the importance of retaining existing jobs and utilizing available labor skills. The proposed biomass facility will maintain current employment at the S.D. Warren mill and will create additional jobs for wood harvesters and truckers (see Sections 3.2.7 and 3.3.10).

The Portland Area Comprehensive Transportation Study (PACTS) update includes a short-range, systemwide transportation systems management plan. A revised interim draft report of this plan, outlining high priority projects, was released in November of 1978. Included in the draft are action proposals for eight projects within the city of Westbrook (Joint Venture 1978). Two of these proposals, if implemented, could facilitate the flow of truck traffic to the proposed biomass facility. Conversely, transport of fuelwood to the facility could heighten the need for implementation of these proposals.

One of these proposals calls for improvements along Wayside Drive, an important truck route that bypasses downtown Westbrook and connects into the Westbrook Arterial (see Section 2.1.10). Synchronizing the traffic signals and widening the road surface of Wayside Drive (Joint Venture 1978) would facilitate access to the biomass facility for trucks approaching from the north and west.

The second proposal calls for traffic signal additions, curb radius increases, and island reconstruction at the intersection of Cumberland and Warren Avenues, adjacent to the S.D. Warren mill site (Joint Venture 1978). These improvements would ease the flow of traffic at the intersection as trucks entered and left the proposed plant site.

Westbrook

In February of 1977 the planning board of Westbrook, Maine, released an update of the city's Comprehensive Plan, which serves Westbrook as an overall development policy framework (WPB 1977). The proposed biomass facility is consistent with Westbrook plans; it will be located in an area designated for industrial use by

both the land use plan and the zoning map (see Figure 4.1.3-A and 4.1.3-B). Although the Comprehensive Plan expresses the goal of reducing development along the Presumpscot and of increasing public access to the river (WPB 1977), neither the land use plan nor the zoning map includes the proposed biomass facility site in their nondevelopment classifications. On the land use plan in Figure 4.1.3-A, S.D. Warren's property west of the Presumpscot River, site of the proposed facility, is excluded from the "resource conservation" district located along the river. Similarly, none of the construction associated with the proposed plant will be located within the "shoreland control" corridor.

FIGURE 4.1.3-A: WESTBROOK LAND USE PLAN IN PLANT SITE AREA

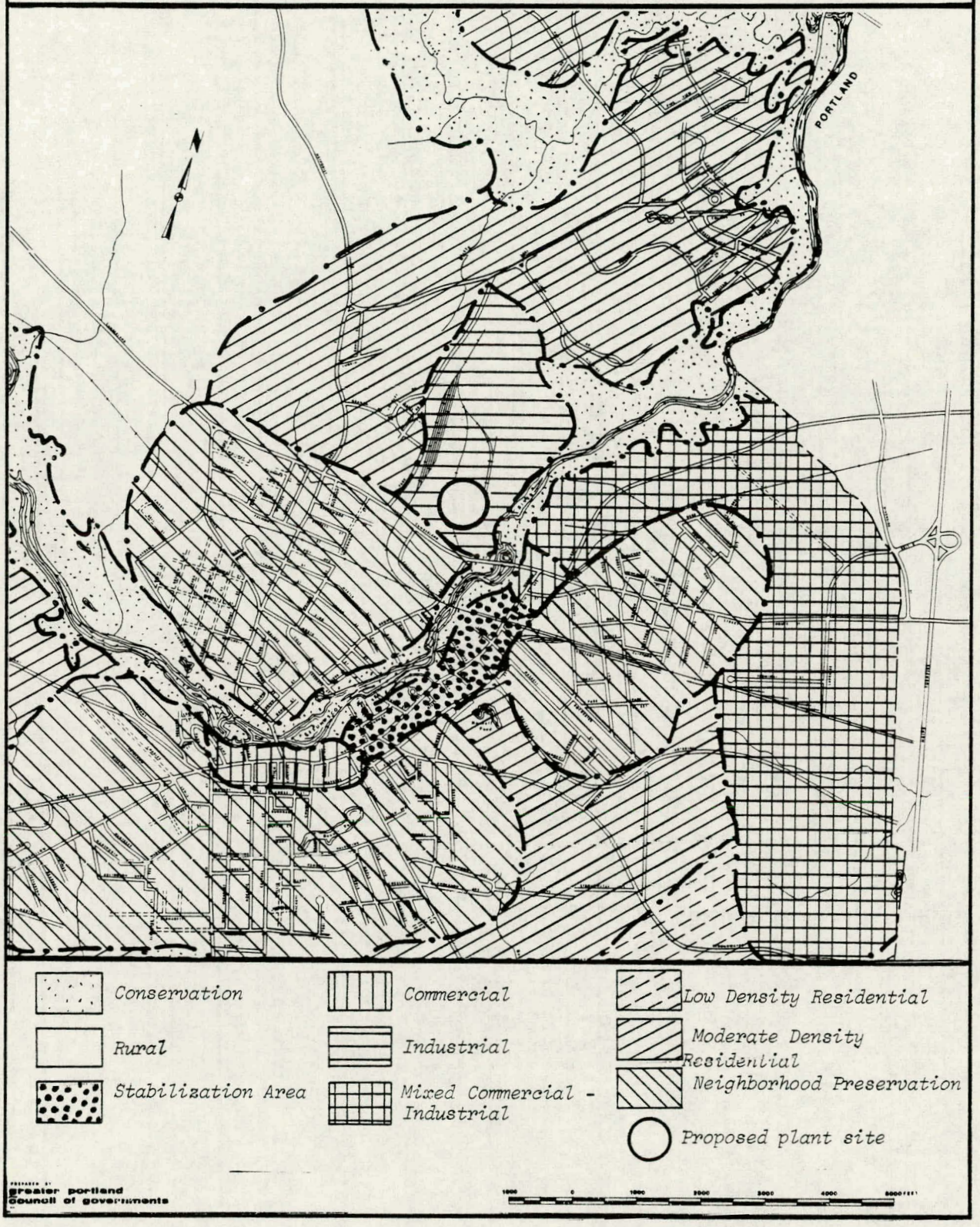
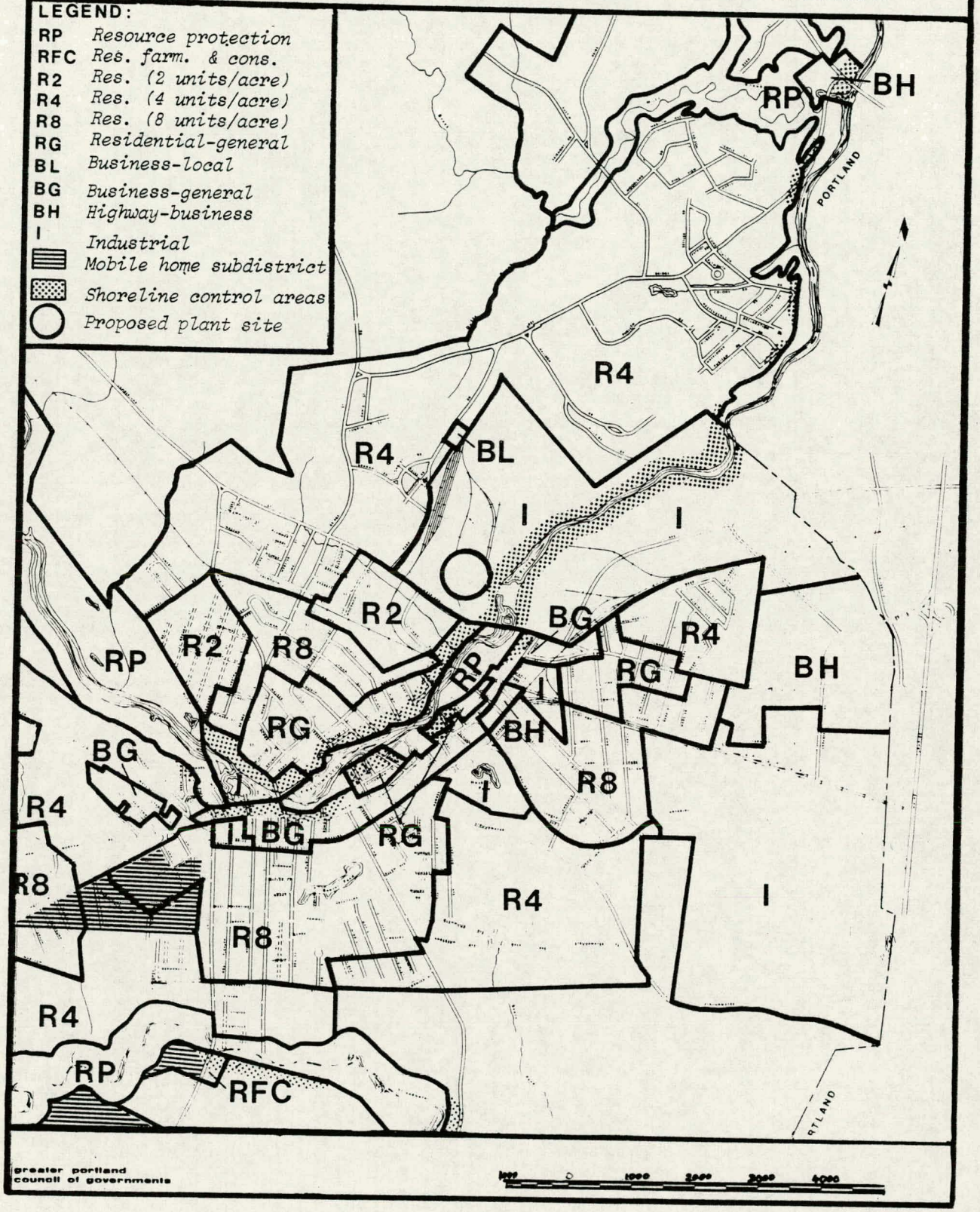


FIGURE 4.1.3-B: WESTBROOK ZONING DISTRICTS IN PLANT SITE AREA



4.2 GOVERNMENT AGENCY APPROVAL

The U.S. Environmental Protection Agency (EPA) and the Department of Environmental Protection of the state of Maine have been advised of the nature of the proposed project and have provided guidance on the required permits for construction and operation of the facility. At this stage, no applications for permits or licenses have been filed. The following summarizes the permits and licenses that must be obtained before the plant may be built and operated.

4.2.1 Federal Government

An air pollution emission permit will be required from the EPA before plant construction and operation. This permit is required under the authority of the Clean Air Act of 1977, as amended.

A pollution discharge permit will be required from the EPA under the National Pollution Discharge Elimination System requirements. These requirements are based on the Federal Water Pollution Control Act of 1972, as amended. Before this permit can be issued, the agency must determine whether the facility constitutes a new source of pollution or an existing source. This determination will alter the permit requirements.

The proposed plant will require a license from the Federal Energy Regulatory Commission in order to sell electric power in interstate commerce through the Central Maine Power Company and NEPOOL, unless the commission determines that the plant is exempt from the requirement as a qualifying cogeneration facility under the Public Utilities Regulatory Policies Act of 1978 (PL 95-617).

The Federal Aviation Administration will require submission of a Notice of Proposed Construction and Alteration (FAA Form 7460-1) and will issue a notice of required lighting for the stack.

4.2.2 State Government

An Air Discharge License is required from the Maine Board of Environmental Protection with the advice of the Bureau of Air Quality Control. This license is required under the authority of the Protection and Improvement of Air Act of 1969, as amended (Maine Revised Statutes Annotated, Title 38, 590).

A Wastewater Discharge License is required from the Board of Environmental Protection, with the advice of the Bureau of Water Quality Control, under the authority of the Protection and Improvement of Waters Act of 1971, as amended (Maine Revised Statutes Annotated, Title 38, 413-414). In addition, if landfill capacity has not been found at an existing approved site, a new site would have to be approved under the authority of the Solid Waste Disposal Act, as amended in 1972 (Maine Revised Statutes Annotated, Title 38, 1301-1308).

A Site Location of Development License is required from the Board of Environmental Protection, with the advice of the Bureau of Land Quality Control under the authority of the Site Location of Development Act of 1970, as amended (Maine Revised Statutes Annotated, Title 38, 481-489).

A Certificate of Public Convenience and Necessity is required from the Maine Public Utilities Commission, under the Maine Revised Statutes Annotated, Title 35, 590, if the power plant is classified as a public utility and is not exempted by the Federal Energy Regulatory Commission.

4.2.3 Local Government

A building permit for any new structure or surfacing project must be obtained from the City of Westbrook.

4.3 REFERENCES

EOP 1977 — Executive Office of the President, Energy Policy and Planning. The National Energy Plan, (Washington: U.S. Government Printing Office, 1977).

Eyerman 1979 — Eyerman, Mark, Senior Planner, Greater Portland Council of Governments, Portland, ME. Telephone conversation (March 20, 1979).

Goodhue 1977 — Goodhue, Sargent. "What has 208 to do with Logging?", reprinted from Forest Notes (Fall 1977).

Gooley 1979 — Gooley, Walter R., Director, Forest Management, Maine Bureau of Forestry, Augusta, ME. Telephone conversation (February 22, 1979).

GPCOG 1978 — Greater Portland Council of Governments. Regional Development Framework - Strategies for Regional Growth, GPCOG, Portland, ME (1978).

Joint Venture 1978 — The Joint Venture. PACTS Short-Range Plan, Transportation System Management Roadway Element, interim draft report, The Joint Venture: SG Assoc., Inc.; Roger Creighton Assoc., Inc.; Hunter-Ballew, Assoc., Portland, ME (1978).

Jordan 1978 — Edward C. Jordan Co., Inc. Report on Nonpoint Source Pollution, prepared for the Greater Portland Council of Governments, Areawide Water Quality Planning Program, Portland, ME (1978).

MBPR 1977 — See Section 2.4

MDEP 1979 — See Section 2.4.

MOER 1976 — Maine Office of Energy Resources. Maine Comprehensive Energy Plan, vol. I, MOER, Augusta, ME (1976).

MSPO 1978 — Maine State Planning Office, Critical Areas Program. Maine's Natural Areas Inventory, MSPO, Augusta, ME (1978).

NHWSPCC 1978 — New Hampshire Water Supply and Pollution Control Commission. Interim Report-Sediment and Erosion Control, draft, Staff Report No. 86j, NHWSPCC, Concord, NH (1978).

USFS 1973 — U.S. Department of Agriculture, Forest Service, Eastern Region. Guide for Managing the National Forests of New England, U.S. Forest Service Eastern Region Office, Milwaukee, WI (1973).

USFS 1974 — U.S. Department of Agriculture, Forest Service, Eastern Region. Forest Plan-White Mountain National Forest, White Mountain National Forest Offices, Laconia, NH (1974).

USFS 1978 — U.S. Department of Agriculture, Forest Service, Eastern Region. Northern Appalachian - New England State Supplement to USDA Forest Service Environmental Statement Roadless Area Review and Evaluation II, U.S. Forest Service Eastern Region Office, Milwaukee, WI (1978).

WPB 1977 — Westbrook Planning Board. Comprehensive Plan - City of Westbrook, Maine, WPB, Westbrook, ME (1977).

CHAPTER FIVE:

ALTERNATIVES TO THE PROPOSED ACTION

INTRODUCTION

This chapter is designed to provide a comprehensive review of a wide range of alternatives to the proposed action, the commercial demonstration of an industrial cogenerating facility fired with wood fuels. An extensive effort has been devoted to the evaluation of all reasonable alternatives to this project, including some not within the jurisdiction of the U.S. Department of Energy. A number of possible actions were also briefly considered, but, for various reasons, they were found not to be appropriate at present for a commercial-scale demonstration of an alternative energy source.

The critical, descriptive characteristics of the wood-fueled commercial demonstration project at Westbrook are considered to be:

- industrial cogeneration of power;
- the production of 510,000 pounds per hour of industrial process steam;
- the production of approximately twenty-five megawatts of electric generating capacity, some of which would be available to a public utility in southern Maine;
- the consumption of 2,000 tons of wood fuel per day.

Each of the alternatives examined in this chapter offers a different option for one or several of the characteristics of the project listed above. As a whole, the chapter describes the range of possible actions that the U.S. Department of Energy and its contractors have considered.

5.1 NO-ACTION ALTERNATIVE

5.1.1 Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could conclude its support of the project for commercial demonstration of a wood energy system.

5.1.2 Description

The Department of Energy could terminate its financial support of this wood-energy demonstration project at the end of the design and assessment phase. S.D. Warren Company could continue the project independently or could discontinue it. In either case, the company will have to replace its boiler system in the near future. The present boiler system will continue to operate, with an increasing need for maintenance, until it is replaced. In the absence of federal involvement, the characteristics of the replacement facility would depend solely on the company's choice of energy systems and fuel.

5.1.3 Economics

If the Department of Energy withdrew from the project, federal funds presently committed to the planning and construction of the wood-fired facility would be available for other purposes. S.D. Warren Company would have to evaluate the economics of continuing the project without further government support.

5.1.4 Environmental Impacts

The environmental impacts of the continued operation of the existing S.D. Warren energy system are discussed throughout this document as the background against which the impacts of the proposed new system are evaluated (see Chapters 2 and 3). The environmental impacts of replacement systems that the S.D. Warren Company might choose in the place of the wood-fired facility are discussed in other sections of this chapter. The discussion in this section will be limited to the environmental implications of a Department of Energy decision not to support this wood-energy commercialization project.

The Department of Energy proposed to support an advanced system demonstration for the use of biomass as an energy source to meet three major objectives:

1. To demonstrate the commercial viability of such a project and to make available technical design information, financial analyses, and environmental evaluations to others interested in building similar systems;

2. To test, demonstrate, and monitor environmentally sound harvesting systems that could collect wood fuel at a price suitable for energy production; and

3. To evaluate the socioeconomic and environmental effects of operating a wood-fired cogenerating system and of obtaining the wood to fuel it.

The Department of Energy's purpose in proposing this project is to speed the nation's transition from dependence on oil to reliance on environmentally sound, sustainable alternatives.

The principal impacts of the no-action alternative result from the absence of an initiative to demonstrate that locally available fuels that are economically and environmentally sound can at least partially replace oil. The result would be to slow the nation's movement away from dependence on increasingly scarce oil. Specifically, the no-action alternative would fail:

- to provide other industries with publicly available design information for successfully demonstrated, wood-fired cogeneration systems;

- to provide other industries with a detailed financial analysis of the feasibility of converting oil-fired energy systems to wood-fired systems;

- to make available environmental information that could reduce the cost and delays for industries desiring to construct and operate wood-fired boilers;

- to demonstrate that wood could be harvested and collected from small, non-industrial private forests at a price suitable for energy production;

- to provide a publicly supported project from which crucial information concerning the environmental impacts of wood combustion could be obtained;

- to provide a publicly supported project from which the environmental impacts of intensive, whole-tree harvesting could be evaluated and the long-term effects on nutrient budgets and forest productivity assessed;

- to provide a publicly supported project to test the effects of the wood energy market on traditional wood markets and non-consumptive uses of the forest resource; and
- to stimulate public interest in alternative energy projects.

5.1.5 Relationship to National, State, or Local Plans and Policies

The no-action alternative conflicts with policies established by both the U.S. Department of Energy and the Maine Office of Energy Resources. Both agencies are committed to investigating and demonstrating alternative energy sources appropriate for various end uses (DPR 1978; MOER 1976).

5.1.6 Summary of Long-term Effects

The no-action alternative would delay the widespread use of wood as an energy source and result in foregone opportunities for understanding the unanswered socioeconomic and environmental questions relating to the use of wood to produce energy. The questions and issues which this project seeks to resolve are central to the successful introduction of wood as an important transitional energy source. Escalating pressures for alternative energy sources could generate unwise decisions regarding wood energy if a sufficient body of knowledge and experience is not publicly available. The no-action alternative hinders the generation of this information.

5.2 ALTERNATIVES TO PROPOSED COGENERATING FACILITY

The alternatives described in this section are intended to describe methods of generating or conserving steam and electricity in a cogenerating facility at the S.D. Warren mill site. The principal characteristic of the proposed facility used in the evaluation of these alternatives is its capacity to produce 510,000 pounds of process steam per hour and 25 megawatts of electricity.

5.2.1 No New Capacity

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could decide not to support the installation of any new generating capacity at the Westbrook mill and S.D. Warren Company could decide not to replace its existing boiler facilities on its own.

Description

In the event that S.D. Warren Company decided to rely on its existing generating capacity, the operational characteristics of that facility would remain essentially the same as they are at present. The only significant difference would be the need for additional maintenance of the generating facility as it aged. Also, the necessary supplies of residual oil, currently the plant's primary fuel, could become difficult to obtain in the future. It is expected that a combination of these factors would ultimately require shutdown of the entire Westbrook pulp and papermaking operation.

The severe socioeconomic dislocations resulting from the elimination of the 2,176 jobs at the mill and the additional 8,704 indirect jobs in the community (Finn 1979a), plus the substantial loss of local income from plant taxes, payroll, and purchases, would result in substantial hardship in the region. The Scott Paper Company and its subsidiary, the S.D. Warren Company, intend to continue operation of the Westbrook mill for the indefinite future (Rolfe 1978). For these reasons, the no new capacity option is not considered a feasible alternative.

5.2.2 Conservation

Policy Statement

As a partial alternative to the proposed action, the U.S. Department of Energy could assist the S.D. Warren Company to implement a major conservation effort within the mill complex. Under this alternative, S.D. Warren Company would still need to replace its energy system, but the new system could be reduced in size in proportion to the energy savings resulting from the conservation program.

Description

By reducing the amount of energy consumed in the production of paper, S.D. Warren Company could conserve fuel and reduce the capacity and cost of its replacement boiler system. Energy conservation efforts have been underway throughout the pulp and paper industry over the past ten years, as indicated in Table 5.2.2-A. The diversity of energy-consuming processes in the industry and the unique character of each mill dictates that an active conservation effort consider many possible methods of reducing use. Energy conservation can be achieved through relatively minor adjustments in current paper-making processes or through replacement of existing processes with new, more efficient systems such as the Rapson pulping process (see Appendix J). Although the retrofitting effort necessary to install a new pulping process is substantial, the Rapson process could save approximately 2.75 x 10^6 Btu per ton of pulp or 9 percent of the 1977 average consumption per ton of writing paper at integrated mills (Hein & Lower 1978).

S.D. Warren Company has undertaken a variety of conservation measures over the past seven years (see Appendix J) and estimates that further reductions of about 10 percent of current energy use are feasible in the near term (Rolfe 1979). The company's recent improvements have focused on improved utilization of existing steam generating capacity, accelerated maintenance of steam systems, and "housekeeping" measures such as insulation projects.

TABLE 5.2.2-A: ENERGY CONSUMED IN PULP AND PAPER INDUSTRY

(10^6 Btu/ton product)

	1971	1972	1977	Short-term Potential
Pulp, Paper, and Paperboard Industry[1]		32.6	31.2	
Writing and Printing Paper Industry	33.5[2]		27.3-30.5[3]	24.2[4]
S.D. Warren Company[5]		42.0	40.0	37.2-38.0

1. *Derived from API 1978a, 1978b.*
2. *Derived from Gordian 1975.*
3. *Source: Hein & Lower 1978.*
4. *Figures from state-of-the-art new mill, reported by Broglio 1979.*
5. *Source: Rolfe 1979.*

Economics

Because of the difficulty in accurately estimating the potential energy savings at the Westbrook mill and the processes that would be affected, it is not possible to describe the specific economic implications of an energy conservation program. Conservation efforts at Westbrook in the recent past, however, have clearly been effective and are judged to be economically justifiable (Rolfe 1979).

Currently, S.D. Warren Company plans to replace worn-out equipment with more energy-efficient equipment as part of normal plant maintenance (Rolfe 1979). Experience at pulp and paper mills around the country indicates that many of the potential energy-saving process changes will produce excellent returns on investment (see Appendix J).

Environmental Impacts

Construction and operation impacts. The construction phase of the energy conservation program would have no discernable impacts beyond those associated with normal mill maintenance programs. The conservation program would reduce thermal emissions in both air and wastewater streams during operation. In the Westbrook area, water quality would benefit from these reductions. The actions taken to reduce and reclaim waste heat would generally increase the internal recycling of exhaust air, process water, and other fluids (see Appendix J).

The socioeconomic impacts of a conservation program would stem from enhanced economic viability of the mill's operations over the long term as a result of its lessened sensitivity to energy costs. These energy savings would not appreciably lessen the regional energy demand unless they were achieved as part of a regionwide effort.

Fuel procurement and transportation impacts. The conservation alternative would reduce the impacts associated with fuel procurement and transportation. The nature of these impacts depend on the characteristics of the proposed facility and are described elsewhere in this document.

Relationship to national, state, or local plans and policies. The Energy Policy and Conservation Act of 1975, as amended, established a national policy of industrial energy conservation which has taken the form of a voluntary industrial program administered by the Department of Energy. A conservation program at the Westbrook mill would be compatible with this policy.

Summary of long-term effects. The long-term effects of this alternative would be a reduction in thermal emissions, wastewater effluents, and fuel consumption per ton of paper produced. Improvements could be expected in water quality and aquatic ecosystems as well as in local air quality. Long-term socioeconomic effects would result from the enhanced economic viability of the Westbrook mill.

5.2.3 Purchase of Steam

Policy Statement

As an alternative to the proposed action, the S.D. Warren Company could attempt to purchase steam.

Description

If a nearby producer of steam or steam-electric power had excess steam available, the S.D. Warren Company could obtain a right-of-way and construct a steam line to transport the energy from its point of origin to the Warren complex.

This alternative is not feasible. The S.D. Warren Company is the largest consumer of steam in the Greater Portland area, using 483,000 pounds per hour (Finn 1979a). There are no major steam generating facilities in the Westbrook area with sufficient surplus or waste capacity to supply this amount of steam (Atlass 1978).

5.2.4 Coal

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a coal-fired

cogenerating facility producing 510,000 pounds of steam per hour and twenty-five megawatts of electricity, as a replacement for the existing oil-fired facility at the Westbrook mill.

Description

The generation of steam and electricity in coal-fired facilities is a well-proven and widely available technology. The site, raw materials, and energy transmission requirements of this alternative would be similar to those described in Chapter 1 for the proposed wood-fired plant. There are significant differences in fuel requirements and pollution controls between wood-fired and coal-fired plants.

A coal-fired plant cogenerating a total of 510,000 pounds of steam per hour would require approximately 171,000 tons of coal annually (calculated from data in Sherwood & Meadows 1978; Hall et al. 1976; Dvorak et al. 1977). Historically, New England's coal has come from Appalachian fields, with the northern mines supplying Maine's needs. This condition is expected to continue into the foreseeable future (Edelston & Rubin 1976). Reserves in the northern Appalachian fields are estimated at 66 billion tons and are in large part recoverable only from underground mines (MITRE 1975).

Railroad is the most economical means of transporting the required amount of coal to inland New England sites (Graham 1978). Approximately 1,680 railcar loads annually would be needed to fuel the Westbrook facility.

Once delivered to the site, the coal must be stored and handled in a way that minimizes dust and contaminated runoff. An estimated .2 acres would be required for a 45-day supply pile (Dvorak et al. 1977). Particulate emissions control equipment would be similar to that employed on the proposed wood-fired plant. Additional pollution control equipment would be needed to control sulfur oxides. Sulfur dioxide scrubber sludge, recovered particulates, and boiler ash would be disposed of in settling ponds and ultimately in landfills. An estimated 27.15 acre-feet per year would be required for the disposal of these materials (Le, Rubin & Meier 1978).

Economics

The construction, operation, maintenance, and fuel costs for a 50-megawatt coal-fired cogenerating facility are outlined in Table 5.2.4-A. Some additional costs might be incurred as the result of sulfur dioxide scrubber sludge and ash disposal operations.

The unit production costs of this alternative are subject to many variables. The existing tax climate, location of the plant, and the financial status of the owner firm would influence the costs of capital, operation, maintenance, and fuel. The costs presented in Table 5.2.4-A provide an estimate of installed capital costs, annual operating and maintenance costs, and fuel costs. These estimates indicate that this alternative is at least marginally commercial and that consideration of its environmental impacts is justified.

Environmental Impacts

Construction impacts. The impacts of constructing a coal-fired cogenerating facility are similar to those associated with the wood-fired facility described in Section 3.1. A slight reduction in erosion and sedimentation might result from the reduced site preparation needed for the smaller coal storage area. This reduction, however, would be balanced by the need to construct larger settling ponds for scrubber sludge and boiler ash. The installation of the additional pollution control equipment could require a slightly larger work force.

Operation impacts. Operation of a coal-fired plant would affect air quality, water quality, land use, and human health. The impacts of the coal facility on local employment and noise levels are similar to those described in Section 3.2 for the wood-fired facility.

The airborne contaminants of most concern include sulfur dioxide, nitrogen oxides, carbon monoxide, particulates, hydrocarbons, and trace elements. The estimated emission of these materials from a 50-megawatt coal-fired cogenerating facility are outlined in Table 5.2.4-B. An additional source of emissions is the coal handling and storage operation. Coal dust from this

TABLE 5.2.4-A: ESTIMATED CAPITAL, OPERATING AND MAINTENANCE, AND FUEL COSTS FOR A 50-MW COAL-FIRED COGENERATING FACILITY[1]

	1979 Dollars *(millions)*
Installed Capital Cost[2]	66.0
Annual Operating and Maintenance Cost[3]	1.6
Annual Fuel Cost[4]	7.9

1. *These estimates will vary substantially from site to site and should be considered only approximations.*
2. *Calculated from Manar 1979b.*
3. *Assumed to be 2.5% of installed capital cost: Manar 1979a.*
4. *Sources: Harvey 1978; Graham 1978; Hall et al. 1976. Based on 171,000 tons/year at $46/ton.*

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source could be effectively controlled, however (Dvorak et al. 1977).

Water quality can be affected if leachate from the coal pile or waste disposal areas reaches ground and surface waters. The leachate contains acids, trace metals, and suspended solids, and has a high chemical oxygen demand (Dvorak et al. 1977).

Both the air and water contaminants have impacts on local ecosystems. Sulfur dioxide and nitrogen oxides have been shown to damage vegetation and contribute to the "acid rain" phenomena. Low levels of trace elements can damage components of an ecosystem over time by interfering with reproductive processes and by direct poisoning (Dvorak et al. 1977).

The health effects associated with the coal-fired power plant's environmental contaminants, particularly the airborne emissions, most often take the form of aggravated respiratory and cardiovascular diseases. Some of the contaminants, including the trace elements and hydrocarbons, have been shown to have direct toxic effects (Dvorak et al. 1977). A quantitative estimate of the number of persons affected by these processes is beyond the scope of this analysis.

Concern has been expressed over the radioactive emissions resulting from the combustion of coal (McBride et al. 1978). Although insufficient data was available to estimate the possible radioactive emissions from a 50-megawatt coal-fired facility, analysis of Pennsylvania coal samples showed a range of uranium concentrations between 20 and 190 parts per million (Dvorak et al. 1977).

Fuel procurement. The impacts of mining coal are qualitatively similar to the operational impacts. Acid mine drainage, containing trace elements and high levels of dissolved solids, can have major impacts on local aquatic ecosystems. Federal water quality standards and coal mining regulations have required the implementation of a variety of mining procedures and wastewater treatment methods to control these impacts.

Coal mining involves significant health and safety hazards although the incidence of accidents has been reduced by the

implementation of federal health and safety standards (MESA 1975). Occupational illnesses related to the inhalation of coal dust affect underground miners, although the increment of coal demand from this facility is not expected to result in a discernable increase in these illnesses.

Transportation impacts. The transportation of fuel for the coal-fired facility would have no significant environmental impacts. The slight air and water quality impacts that will occur are outlined in Appendix J. The noise levels associated with the periodic coal trains should not be important in relation to the existing noise levels of Westbrook, the S.D. Warren mill, and current rail traffic.

Relationship to national, state, or local plans and policies. The coal-fired alternative would be compatible with the purposes of the Power Plant and Industrial Fuel Use Act of 1978, commonly referred to as the Coal Conversion Act. This act generally prohibits the use of natural gas and petroleum in large new facilities, while encouraging the conversion of existing facilities to coal. Federal and state air and water quality goals could be achieved with the application of suitable control technologies.

Summary of long-term effects. The construction and operation of a coal-fired cogenerating facility would have long-term effects similar to those outlined for the proposed wood-fired power plant with the major exceptions described below.

For the life of the plant, local air quality would be affected by the emissions of the contaminants outlined in Table 5.2.4-B. The emission of the trace elements contained in the coal could have effects lasting beyond the life of the plant, although these would be expected to be minimal. The effects on human health of sulfur dioxide, nitrogen oxides, and particulate emissions may also be perceptible beyond the life of the plant.

The disposal of boiler ash and scrubber sludge represents a long-term problem with implications for land use and water quality. Adequate treatment of these materials and isolation of any hazardous residues is necessary to avoid serious surface and

groundwater contamination. An analogous, though lesser, issue involves the runoff from the coal storage pile, which must be diverted and treated to avoid water quality deterioration.

The coal mining undertaken as a result of the demand created by this facility will have small but incremental long-term effects on miners' health and on land and water quality.

5.2.5 Oil/Wood

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support the installation of a 50-megawatt cogenerating facility fired with oil and wood fuels at the Westbrook mill. The wood-to-oil ratio, on a Btu-input basis, would range between one to one and three to one, depending on the economic availability of wood fuel. For the purpose of this discussion a one-to-one mix will be assumed.

Description

The use of a multifuel boiler requires separate storage, handling, and firing equipment for the liquid and solid fuels. While the S.D. Warren mill is already set up to handle oil, additional facilities would be required for the wood fuel. Pollution control equipment would be required to handle emissions from both fuels. The particulate control equipment described in Chapter 1 would adequately control the wood fly-ash emissions. The use of low-sulfur oil or sulfur dioxide scrubbers would be needed to control the oil-related sulfur emissions. Approximately 340,000 tons of wood and 385,000 barrels of oil would be required annually. Other characteristics of an oil/wood facility are quite similar to those presented for the proposed action (see Chapter 1).

Economics

The costs of this facility are presented in Table 5.2.5-A. With the exception of fuel, the annual costs of an oil/wood-fired boiler are identical to those of the proposed wood-only installation. The extra fuel-firing capacity does not significantly increase the overall plant costs; in fact, reduction in wood-

TABLE 5.2.5-A: ESTIMATED CAPITAL, OPERATING AND MAINTENANCE, AND FUEL COSTS FOR A 50-MW OIL/WOOD COGENERATING FACILITY[1]

	1979 Dollars *(millions)*
Installed Capital Cost[2]	63.0
Annual Operating and Maintenance Cost[3]	1.6
Annual Fuel Cost[4]	9.9

1. *These estimates will vary substantially from site to site and should be considered only approximations.*
2. *Calculated from Manar 1979b.*
3. *Assumed to be 2.5% of installed capital cost: Manar 1979a.*
4. *Based on fuel prices of $14.80/barrel (EIA 1978) and $12.50/ton (Allison 1979).*

handling costs may reduce operating costs slightly. The existing oil-handling and storage facilities at the S.D. Warren mill are adequate for the oil/wood boiler.

Adjusted fuel requirements represent a change in the annual cost of the facility, however. Current oil prices and the expected wood fuel prices, $14.80 per barrel (EIA 1978) and $12.50 per ton (Allison 1979), respectively, result in a total annual fuel cost of $9.9 million.

The unit production costs of this alternative are subject to many variables. The existing tax climate and the financial status of S.D. Warren Company, among other factors, would influence the costs of capital, operation, maintenance, and fuel. However, the estimates in Table 5.2.5-A indicate that this alternative is at least marginally commercial and that consideration of its environmental impacts is justified.

Environmental Impacts

Construction impacts. The impacts of constructing a 50-megawatt oil/wood cogenerating facility would be identical to those associated with the proposed all-wood facility.

Operation impacts. The operation of an oil/wood facility would result in a wide range of environmental impacts. While many of these impacts would be similar in nature to those of the wood-fired and coal-fired facilities, described in Chapter 3 and Section 5.2.4 respectively, the quantities of pollutants emitted would be quite different. The projected emission of air pollutants and generation of solid wastes are presented in Table 5.2.5-B. A one-to-one ratio of fuels was assumed; however, it should be noted that as the proportion of wood fuel increases, the quantities of wood ash and particulates generated also increase, while the contaminants characteristic of oil decrease. The impacts of oil and wood emissions are described in Sections 5.2.4 and Chapter 3.

Several trace elements are present in fuel oil including arsenic, nickel, vanadium, and yttrium. Emission of these materials may pose ecological and human health hazards (OWHM 1974; Newkirk 1976; Magee et al. 1973).

TABLE 5.2.5-B: ESTIMATED AIR EMISSIONS AND SOLID WASTE FLOWS FROM A 50-MW OIL/WOOD COGENERATING FACILITY

Air Pollutants [1]	Emissions [2] *(tons/year)*
Nitrogen Oxides	1,357 - 1,788 [3]
Sulfur Dioxide	431
Sulfur Trioxide	3
Carbon Monoxide	339
Particulates	161
Hydrocarbons	43

Solid Wastes	Quantity *(tons/year)*	*(acre-feet/year)*
Collected Ash [4]	6,766-14,547	-
Scrubber Sludge [5]	6,621	3.8

1. *Emissions from oil combustion are derived from EPA 1976. Emissions from wood are adapted from the analysis of the proposed action: see Appendix B.*
2. *Assumes 90% reduction in SO_x emissions and 99.5% reduction in particulate emissions.*
3. *Emissions depend on choice of firing mode for oil, i.e., tangential or horizontal.*
4. *Calculated assuming 2-4.3% ash content in wood: Hall et al. 1976.*
5. *Source: Le, Rubin & Meier 1978.*

Fuel procurement. The environmental impacts of oil procurement occur principally during the refining process. Sulfur oxide, nitrogen oxide, and hydrocarbon emissions and the oxygen demand of wastewater effluents are considered to have the most significant impacts (SPPP 1975). The quantities of air contaminants emitted during the refining process are roughly comparable to those emitted during boiler operation on a Btu basis (SPPP 1975).

For the most part, proven methods exist for the control of effluents and emissions from fuel procurement operations. No incremental ecological and socioeconomic impacts would result from the procurement of oil since this alternative would decrease the current oil consumption of the Westbrook mill by approximately 265,000 barrels annually.

The impacts of procuring the wood fuel are described in Chapter 3. These impacts would be reduced in proportion to the smaller amount of wood consumed under this alternative.

Transportation. The environmental impacts of transporting the fuel oil would depend in large part on the source of the crude oil and where it is refined. Most of New England's residual fuel oil is imported by tanker or barge from foreign sources (Bronheim 1978) and shipped by rail to the points of use. The oil/wood alternative would reduce the existing S.D. Warren Company requirement for tank cars by approximately eight to seventeen cars per week (calculated from S.D. Warren 1978; Lapikas 1979). The impacts of the transportation of wood are described in Chapter 3.

Relationship to national, state, or local plans and policies. A new 50-megawatt oil/wood cogenerating facility would conflict with the national policies established by the Powerplant and Industrial Fuel Use Act of 1978. Final regulations for the implementation of the Act have not yet been promulgated, however. The policies of the Maine Office of Energy Resources generally support both the use of wood fuels and cogeneration (MOER 1976).

Summary of long-term effects. The most significant long-term effects of this alternative result from the impact of increased wood demand on the area's forest resources. This demand, as

described in Chapter 3, would have lasting implications for the management of forest and related ecosystems. Alternative uses of these resources for recreation, water quality management, and other forest industries could be affected, both positively and negatively.

An additional long-term effect of this alternative would be to continue and extend the region's dependence on oil, a finite and uncertain source of energy. This continued dependence would appear to be in conflict with national policy.

5.2.6. Alternative Supplementary Fuels

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support the installation of an energy system at the S.D. Warren mill that utilized limited quantities of supplementary fuels in addition to wood, the primary fuel source. These supplementary fuels, which include used railroad crossties, discarded rubber tires, and processed municipal solid waste, could provide up to 22 percent of the total annual fuel requirements. This alternative would reduce the required amount of fuelwood.

Description

The facility design requirements for combustion of supplementary fuels are identical to those for the proposed wood-fired system except for additional handling and storage systems. The use of supplementary fuels is limited by their combustion characteristics and availability.

Municipal solid waste can be burned in combination with wood but not in quantities greater than 10 percent of the total fuel input. Boiler corrosion can result if solid waste exceeds 10 percent (Cover 1978). The municipal solid waste would have to be sorted, shredded, and baled in order to avoid boiler damage (Ruane 1977a). No such processing facility currently exists in the Westbrook area. There are, however, approximately 430 tons per day of raw municipal solid waste collected within a twenty-mile radius of Westbrook (GPCOG 1977). About 120 tons per day at 25 percent moisture content (at 6,500 Btu per pound) would supply

10 percent of the proposed boiler's required Btu input.

Debeaded and shredded rubber tires can also be burned, but not in a mixture exceeding 15 percent of the total fuel. A greater proportion of tires can cause damage to the wood boiler, as rubber has a much higher heat content than wood (about 15,000 Btu per pound). There are roughly twenty-one tons of scrap rubber tires available per day in the Westbrook area from five tires companies (Detwyler 1978; Harmon 1978; Hobart 1978; Hunt & Babcock 1978). This amount totals about 7 percent of the annual Btu input required for the proposed wood-fired boiler.

Old railroad crossties may be chipped and burned along with other wood fuel since the fuel value (6,250 Btu per pound at 25 percent moisture content: Johnston 1978) and combustion characteristics are similar. About fifty-seven tons of crossties are available per day from three railroad companies in southern Maine (Bell 1978; Peters 1978; Hughes & Denio 1978). This amount would supply 5 percent of the plant's total Btu input requirement.

Economics

Prices for old crossties sold in quantity as fuel would probably range from $12.00 to $14.50 per ton delivered (Johnston 1978). Municipal solid waste and scrap rubber tires are both considered to be waste problems and are disposed of at a cost to the producer. Disposal costs for unprocessed municipal waste in the Westbrook area range from $5.00 to $9.00 per ton (Allen 1978). The cost of disposing of rubber tires is approximately $0.15 per tire (about $14.00 per ton) (Noyes 1974). These disposal costs do not necessarily represent the potential fuel costs of these materials, should a market be created. The current nature of these materials, however, does indicate that they would be available at a reasonable cost.

Environmental Impacts

Construction impacts. The construction impacts of the energy facility using supplementary fuels are the same as those described in Section 3.1.

Operation impacts. The environmental impacts of operation with supplementary fuels are similar to those when wood is burned

alone. Differences in air emissions and the chemical content of boiler ash are significant, however.

- Municipal refuse. The firing of processed municipal solid waste in combination with other solid fuels results in slight increases of particulate and chlorine emissions, but not to an extent that state air quality standards are violated (Ruane 1977a) More boiler ash is produced if municipal solid waste is burned as a supplement. The ash contains inert material such as metal and glass as well as some water-soluble compounds (primarily hydrocarbons) (Ruane 1977a). Due to the highly variable chemical composition of municipal solid waste, it is impossible to predict precisely the kind or concentration of materials present in leachate from ash disposal sites. It is possible that potentially harmful substances may be present, however. Nitrates, phosphates, chlorides, sulfates, sodium, potassium, and iron may all be present in varying concentrations (Rubel 1974).

- Rubber. Although the combustion of rubber yields very high particulate emissions, these can be controlled when the fuel is burned in small quantities with wood. Sulfur dioxide emissions will not be increased. Nitrogen oxide emissions may increase slightly but can be controlled (Meffert 1978). Zinc oxide emissions may also occur, but it is not known in what concentrations. Zinc oxide fumes have a low toxicity to humans in most cases, although some researchers feel that the compound might be carcinogenic in high concentrations over extended periods (Sax 1975). The presence of zinc in the boiler ash may require special disposal precautions since zinc is a heavy metal that may be toxic in high concentrations to aquatic or animal life.

- Railroad crossties. The emissions from incompletely burned crossties will contain black tar creosote smoke. The amount should not be high if crossties are burned as a supplementary fuel only. Combustion of creosote currently would not violate state opacity and particulate standard but the compound may become classified as a hazardous substance (Thomae 1978). If this occurs, crossties may not be burned. Coal tar pitch volatiles are recognized carcinogens (Sax 1975).

Small amounts of herbicides may be present on crossties due to periodic weed control spraying by railroad companies. Combustion would destroy most of these herbicides and their residues. However, the long-term toxicity to animal life of some of the herbicides used, especially 2,4-D and 2,4,5-T and their byproducts, are controversial (Heinrichs 1979; Popovich 1978). It is not known whether or not these substances are amplified through the food chain.

Fuel procurement impacts. The supplementary fuels described in this section are generally regarded as waste materials and their reuse is minimal. Therefore, the effect of using them would be to alleviate local waste disposal problems. In addition, the amount of wood required for fuel could be reduced.

Transportation impacts. The transportation impacts would be similar in nature to those associated with the trucking of wood chips for the biomass facility. The magnitude of total transportation impacts would be reduced by the higher heat content of the supplementary fuels.

Relationship to national, state, or local policies and plans. The use of the supplementary fuels described in this section would not conflict with any existing policies or plans. It is encouraged by the federal Resource Conservation and Recovery Act of 1976 and would be compatible with local waste disposal plans.

Summary of long-term effects. The principal long-term effects of burning supplementary fuels center around the potential release of contaminants, the reduction of the primary fuel requirements, and the alleviation of local solid waste disposal problems. Environmental contaminants, particularly in the form of airborne particulate and leachable hazardous materials, can be controlled by existing methods. The limited use of supplementary fuels also mitigates the impacts of these contaminants. The impacts associated with combustion, procurement, and transportation of the fuelwood would be reduced in proportion to the use of the supplementary fuels. The use of solid waste fuels would alleviate the pressures on regional and local sanitary landfill operations.

5.2.7 Other Fuels

Oil

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a 510,000 pound per hour oil-fired cogenerating facility at the Westbook mill as a means of demonstrating and encouraging industrial cogeneration.

Description. The Powerplant and Industrial Fuel Use Act of 1978 specifically prohibits the use of petroleum as a primary energy source in new major fuel-burning installations. A major fuel-burning installation is defined as a facility with boilers designed to consume fuel at a rate of 100 million or more Btu per hour. A cogenerating facility producing 510,000 pounds per hour consumes well in excess of this threshold, with a fuel consumption capacity on the order of 600 million Btu per hour. The Act further allows the Secretary of Energy to order the conversion of existing facilities from natural gas or petroleum to coal or other alternative fuels.

Because of these prohibitions, an oil-fired cogenerating facility is not a feasible alternative.

Natural Gas

Policy statement. The U.S. Department of Energy could support a cogenerating plant at S.D. Warren that used natural gas as a fuel.

Description. The Powerplant and Industrial Fuel Use Act of 1978 specifically prohibits the use of natural gas as a primary energy source in new major fuel-burning installations (see discussion above). Because of these prohibitions, a natural gas-fired cogenerating facility is not a feasible alternative.

Geothermal

Policy Statement. As an alternative to the proposed action, the U.S. Department of Energy could support a cogenerating plant that extracts heat in the form of steam from the earth's interior. The steam may be used for industrial processing or to produce electricity.

Description.* Hydrothermal power is naturally available where underground aquifers or water bodies come in contact with hot bedrock. There are many hydrothermal reservoirs in the western United States, but none are known to exist in Maine. However, areas in Maine do exist where hot bedrock lies close to the surface. At these locations, it may be possible to inject surface water into the hot rocks and then extract it in the form of steam via another nearby well.

In order for the water and steam to flow, the hot bedrock must be made porous through fracturing techniques. To date, only hydraulic fracturing has been actively investigated; this technique has been demonstrated successfully at Los Alamos, California. Continuous steam extraction has not yet been achieved, however, due to technical difficulties.

While dry rock geothermal energy may be commercially feasible by the late 1980s, the technology is presently still in experimental and small-scale demonstration stages. For this reason, geothermal energy is not currently a reasonable alternative to the proposed project.

Solar

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a solar-powered cogenerating steam-electric plant.

Description. Two systems have been developed which collect solar radiation and convert it to high temperature thermal energy. The first system, called a central receiver solar furnace, utilizes a field of mirrors (heliostats) to focus the sun's rays on a receiver mounted on a tall tower. This concentrated thermal energy heats water and produces steam. The steam may be used immediately or transferred to a thermal storage system where heat is held for later use (Bereny 1977; Geary & Jones 1977; Williams 1974).

The second system employs a "solar farm" composed of linear, fixed-mirror collectors which concentrate insolation (solar radiation) onto long pipes containing heat-retentive fluids. These

* Source: Waterflow 1977.

fluids flow to a central storage system where the heat is used to produce steam (Bereny 1977; Geary & Jones 1977; Williams 1974). Both systems require a master control unit to coordinate the heliostats and to regulate the delivery of steam and transfer of heat. Conventional steam turbines and electrical generators can be used with either system.

Solar thermal systems are technically feasible. The Department of Energy is funding the development of one five-megawatt demonstration plant and one ten-megawatt pilot plant in the southwestern United States, the region that shows the highest promise for near-term use of solar-powered steam-electric plants. Operation of a large-scale commercial plant is not foreseen, even in that region, until sometime after the mid 1980s (Geary & Jones 1977).

Recent estimates indicate that between 160 and 625 acres would be required at a solar power station to produce the energy to be supplied by the proposed wood-fired boiler (Geary & Jones 1977). S.D. Warren Company currently owns about 180 acres, half of which is occupied by existing plant structures. The company does not have access to sufficient acreage to produce its energy needs with a solar thermal system because the area surrounding its property is either developed or zoned for nonindustrial uses. Furthermore, currently available storage systems to supply energy during cloudy periods must be recharged every three days (Ruane 1977b), whereas the Northeast occasionally experiences as many as six consecutive days without sun.

It is highly unlikely therefore that a commercially viable solar thermal-electric system will be located in Maine in the near future. Due to site restrictions, it would not be feasible for one to be located at the S.D. Warren site in Westbrook.

5.3 ALTERNATIVE METHODS OF GENERATING ELECTRICAL POWER

The alternatives described in this section are intended to describe methods of generating or conserving twenty-five megawatts of electrical power to replace the capacity represented by the proposed facility. These alternatives involve projects which could be undertaken within the area affected by the proposed facility, i.e., within fifty miles of Westbrook, Maine.

5.3.1 No New Capacity

Policy Statement

The U.S. Department of Energy could support a load management and electricity conservation project in Maine as an alternative to building twenty-five megawatts of new cogenerated electric capacity.

Description

This alternative would consist of a concurrent effort to reduce peaks in electricity demand and to reduce the overall consumption of electricity. Load management involves a shifting of peak electricity use to times of the day or year characterized by relatively low demand. This shift can be accomplished through a variety of measures including differential rate structures, remote control by the utility of electrical appliances, and space heat storage. A recent study has indicated that successful load management could reduce the 1985 peak demand for electricity in New England by 2.4 percent or 544 megawatts (ACE 1977).

Conservation of the total amount of electricity consumed can be attained by improving the efficiency of electrical appliances and by reducing the use of such appliances. Conservation programs also could be directed toward reducing unnecessary use of electric space heating and lighting systems. It has been estimated that, in Maine, between 5.7×10^8 and 21.9×10^8 kilowatt-hours of electricity could be conserved annually in 1985 (Jones et al. 1977). This is equivalent to the output of a 92- or 357-megawatt generating facility operating at 70 percent capacity.

This potential for load management and conservation could delay the construction of new electric generating capacity in southern Maine.

Economics

Load management and conservation have been demonstrated to be economically viable in specific situations in the United States (Rodemann 1978; Vumbaco 1978). In addition, load management has been extensively employed in Europe for many years as a means of optimizing the use of baseload generating capacity (Laaspere 1974; Converse 1974). Research also indicates that energy-efficient electrical appliances are economically viable (NEEC 1978) and could be employed to a greater degree.

Environmental Impacts

The environmental impacts of an electric energy conservation program are primarily beneficial. An overall reduction in the amount of electricity consumed would reduce the amount of fuel consumed to generate that electricity. Successful load management would allow more efficient use of baseload generating stations, which typically consume less energy per kilowatt generated than do intermediate and peakload facilities. The result would be to reduce the operating impacts of electric generating facilities. These reductions would occur principally in chemical and thermal emissions to air and water.

An additional effect of a conservation program would be to defer the need for additional generating capacity and the related environmental impacts of construction of new facilities. Discussion of the impacts of construction and operation of energy facilities occurs throughout this document.

Some socioeconomic impacts could also occur. While only 5 percent of Maine's housing units are electrically heated, this use accounted for 12 percent of the total residential electricity consumption in 1977 (Jones et al. 1977). A program to improve the insulation in these homes would generate local employment. While this effect and others similar to it might be considered beneficial, the deferral of constructing new capacity must be considered as negative from the labor viewpoint. It is possible, however,

that a conservation program of significant scope would require the skills of these workers to retrofit new, energy-efficient equipment into existing homes and commercial, industrial, and utility facilities.

A conservation program would be compatible with both the Energy Policy and Conservation Act of 1975 and the National Energy Conservation Policy Act of 1978. These acts established conservation programs and efficiency standards for electrical appliances. This alternative would also be compatible with the policies established by the Maine Office of Energy Resources (MOER 1976).

5.3.2 Purchase of Electricity

Policy Statement

As an alternative to the proposed action, the electric utilities in southern Maine could purchase twenty-five megawatts of electric generating capacity from a utility outside their service areas.

Description

The purchase of electric power as an alternative to the proposed action can be a "firm purchase agreement," a contract between two utilities for the output from a given amount of generating capacity. A utility can also enter into a mutual construction program with other utilities to build new power plants. The latter option allows utilities to supplement their power supplies through ownership of new generating capacity. Central Maine Power Company is the utility presently serving the Portland area and most of southern Maine. Central Maine Power Company in 1977 purchased approximately 110 megawatts of capacity and expects to continue purchasing capacity in varying amounts over the coming years (CMP 1977). As a member of the New England Power Pool (NEPOOL), Central Maine Power Company has a "capability responsibility" calculated under the provisions of the NEPOOL agreement to provide a certain amount of power. Subject to certain restrictions, the purchase of electric power is a means of meeting this responsibility (NEPOOL 1971). NEPOOL itself purchases power from outside the New England area. NEPOOL is expected to purchase roughly 600

megawatts of capacity annually during the next five to ten years (ACE 1977).

Central Maine Power Company also shares in several existing and planned plants which comprise a major portion of its capability responsibility. These shares amounted to 384.6 megawatts of capacity in 1977 and are expected to amount to 1,392.5 megawatts by 1990 (CMP 1977).

Either of these two methods of purchasing twenty-five megawatts of electric generating capacity is a feasible alternative to the proposed project.

Economics

The cost of electric power purchased under a firm purchase agreement, the method most often employed for the acquisition of supplemental power, is determined by establishing a fixed capacity charge and adding an energy charge. The capacity charge, in dollars per kilowatt per year, includes the fixed annual costs and return on investment of the capacity purchased. The energy charge primarily represents the variable fuel costs (Lowery 1979). The cost of electric power obtained from a newly constructed, jointly owned plant is determined on a conceptually similar basis. A comparison of the two methods is difficult, however, due to the variety of conditions which affect the economics of the surplus capacity and the new capacity.

The widespread employment of both practices demonstrates the economic feasibility of purchasing power.

Environmental Impacts

The environmental consequences of purchasing power depend on the choice of purchasing arrangement. If electricity or capacity is simply purchased from a neighboring utility, the environmental impacts are directly proportional to the additional fuel consumed, since the supplier of electricity is utilizing existing surplus capacity.

If, on the other hand, the purchasing utility were to enter into a joint construction effort on a large new plant, the environmental effects of purchasing power would involve an increment of the construction as well as operation impacts. The large new

facilities that are to be built in New England in the future are most likely to be nuclear and coal plants. An estimate of the impacts associated with twenty-five megawatts of capacity in either of these types of power plant is beyond the scope of this analysis. A number of environmental impact statements providing analyses of these impacts have been prepared (BLM 1976; AEC 1974).

Central Maine Power and NEPOOL project a decline over the next ten years in the amount of electricity purchased under contract (CMP 1977; ACE 1977). The environmental impacts of a purchased power alternative therefore will stem principally from the joint construction option.

Relationship to National, State, or Local Plans and Policies

The Public Utilities Regulatory Policy Act of 1978 supports the efficient use of energy-generating resources, including physical facilities and capital. The purchase of surplus generating capacity and joint construction of new capacity both contribute to this goal.

Summary of Long-term Effects

Because most joint construction projects will be for plants that are nuclear- or coal-fired, the purchase of electricity option represents a continued investment in nonrenewable energy systems. This investment will further delay a regional transition to locally available, renewable sources of power. The joint construction option also carries with it the long-term impacts of construction and operation of new plants.

5.3.3 Coal

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a 25-megawatt coal-fired electric generating station in southern Maine.

Description

A 25-megawatt coal-fired facility operating at a capacity factor of .7 would produce 153.3 million kilowatt-hours of electricity per year. This power could be sold to industrial custo-

mers in southern Maine, to the regional electric grid, or to both. With a heat rate of 10,500 Btu per kilowatt-hour, such a plant would require approximately 59,000 tons of coal per year. A 25-megawatt plant would be generally similar to the 50-megawatt coal-fired cogenerating station described in Section 5.2.4. However, the quantities of coal required by the facility would be too small to support the economic use of unit trains for the delivery of the fuel. If the plant were sited at an ocean or deep-water river port, transportation of the coal by barge would provide an economic alternative. Otherwise, the coal would probably have to be delivered by rail freight at relatively high car-lot rates.

Economics

The economic requirements of a 25-megawatt coal-fired electric generating facility are given in Table 5.3.3-A. Unless the plant could be sited near an ocean port with handling facilities to receive coal barges, the unavailability of unit trains for a plant of this size would mandate higher fuel costs than those shown.

The unit production costs of this alternative are subject to many variables. The existing tax climate, location of the plant, and the financial status of the owner firm will influence the costs of capital, operation, maintenance, and fuel. The estimates in Table 5.3.3-A indicate, however, that this alternative is at least marginally commercial and that consideration of the environmental impact is justified.

While this alternative is at least marginally economically viable, an electric utility investing in additional generating capacity would be more likely to seek the economies of scale available in larger coal-fired facilities. For example, Central Maine Power Company is planning to build a 600-megawatt coal-fired plant in Maine and retain 463 megawatts of capacity for its own use, while selling the rest to other utilities (CMP 1977).

Environmental Impacts

The environmental impacts of a 25-megawatt coal-fired electric generating plant would be similar to those described in

TABLE 5.3.3-A: ESTIMATED CAPITAL, OPERATING AND MAINTENANCE, AND FUEL COSTS FOR A 25-MW COAL-FIRED ELECTRIC GENERATING FACILITY[1]

	1979 Dollars *(millions)*
Installed Capital Cost[2]	45.0
Annual Operating and Maintenance Cost[3]	1.1
Annual Fuel Cost[4]	2.7

1. *These estimates will vary substantially from site to site and should be considered only approximations.*
2. *Calculated from Manar 1979b.*
3. *Assumed to be 2.5% of installed capital cost: Manar 1979a.*
4. *Sources: Harvey 1978; Graham 1978; Hall et al. 1978. Based on 59,000 tons/year at $46/ton.*

Section 5.2.4 for a 50-megawatt cogenerating facility. The smaller size of the plant and the reduced fuel requirements would diminish all of the impacts described.

Air emissions and volumes of solid wastes generated by the plant are outlined in Table 5.3.3-B. Although it is assumed that sulfur dioxide scrubbers will be employed as air pollution control devices, it is possible that other means of meeting air quality standards, such as burning low-sulfur coal, could be used.

If the plant were sited on the coast to allow service by coal barges rather than unit trains, air emissions from the transport of coal would be reduced, as towboats emit fewer pollutants per ton of material hauled than do railroad engines (Dvorak et al. 1977). Accidental and routine coal spillages would affect aquatic ecosystems in a manner similar to that described in Section 5.2.4. Fatal accidents associated with coal barge traffic would be lower than those associated with rail shipment (Dvorak et al. 1977).

Location of a coal-fired electrical generating station on a nonindustrial site adjacent to the ocean or a navigable waterway raises concern over the limitation of free access to a public resource. Although the Great Ponds Act in Maine guarantees access to most freshwater areas, public access to the ocean shore is extremely limited in Maine at present.

All other impacts, policy implications, and long-term effects are described in Section 5.2.4.

5.3.4 Alternative Supplementary Fuels

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could assist the development of an electrical generating plant that utilized limited quantities of supplementary fuels in addition to fuelwood.

Description

The nature of this alternative is similar to that described in Section 5.2.6 except that the plant would not be a cogenerating facility. The steam created would be used only to generate electricity and would not be used for heating or processing.

TABLE 5.3.3-B: ESTIMATED AIR EMISSIONS AND SOLID WASTE FLOWS FROM A 25-MW COAL-FIRED ELECTRIC GENERATING FACILITY

Air Pollutants	Emissions[1] *(tons/year)*
Nitrogen Oxides	531.0
Sulfur Dioxide	224.2
Carbon Monoxide	29.5
Particulates	17.7
Hydrocarbons	8.5

Solid Wastes[2]	Quantity *(tons/year)*	*(acre-feet/year)*
Collected Ash	4,879	2.8
Scrubber Sludge	10,803	6.5

1. *Assumes 90% reduction in SO_2 emissions and 99.5% reduction in particulate emissions. Source: EPA 1976.*
2. *Source: Le, Rubin & Meier 1978.*

Therefore it would require less fuel than the plant described in Section 5.2.6 and would not necessarily have to be located at S.D. Warren or a similar industrial facility. The technical restrictions on the percentage of municipal solid waste and rubber that could be burned are the same as those described in Section 5.2.6 (i.e., 10 percent processed municipal solid waste and 10 percent rubber).

A 25-megawatt electric generating plant, operating at a 70 percent plant capacity factor and with a heat rate of 10,500 Btu per kilowatt-hour would require approximately 1.6×10^{12} Btu per year. Ten percent of this figure is equivalent to approximately 12,300 tons of processed municipal solid waste. There would be sufficient supplies of processed municipal solid waste to meet this demand. However, there are only 9,230 tons of rubber available annually, which is enough to supply about 17 percent. There are about eighty-two tons of crossties available per day of plant operation. This amount would supply about 16 percent of the total annual Btu input. The total supplementary fuel contribution would therefore be about 43 percent.

The economics and environmental impacts of this alternative are the same as those described in Section 5.2.6.

5.3.5 Hydroelectric

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could develop twenty-five megawatts of hydroelectric potential in southern Maine. The hydroelectric alternative would supply power to the regional grid from several low-head dams. Hydroelectric plants could be located at renovated existing dams, or they could be new facilities at previously undeveloped sites.

Description

Table 5.3.5-A lists the hydroelectric potential of the larger existing dams and new sites in the river basins of the fuelwood harvest region. In addition, there are sixty-one low-head dams with developable capacities of less than 500 kilowatts that would

TABLE 5.3.5-A: HYDROELECTRIC POTENTIAL IN FUELWOOD HARVEST REGION

	River	Capacity *(Mw)*	Capacity Factor	Annual Output *(10^6 kwh)*	Head Height *(feet)*
New Dam Sites[1]					
		30	.18	47.7	38
Steep Falls	Saco	15	.36	48.0	
Pejepscot	Androscoggin	10	.59	52	22
Lewiston	Androscoggin	30	.49	130	55
Great Falls	Saco	40	.25	87	111
Expanded Dam Sites[2]					
Cataract	Saco	10	.45	40	42
West Buxton	Upper Saco	5.4	.33	16	28
Bonny Eagle	Saco	7.8	.38	26	37

1. *Source: FPC 1977, except figures for 30-Mw facility at Steep Falls, which come from NEFRC 1976.*
2. *Dams currently operating, but with potential for expansion. Source: FPC 1977.*

create a combined electric potential of 222 megawatts (NERBC 1979). Because of existing water flow rates, most of these sites would depend on reservoirs or upstream flow regulation to control their water supply and would produce power to meet peak needs. The availability of water is not a problem for most peaking facilities with reservoirs, although greater-than-average reservoir drawdown may be necessary during periods of draught.

The materials required for construction of a new facility are earth, rock, concrete, lumber, steel, and generating equipment. Renovation of an existing dam requires the same materials but in lesser quantities. For new dams, unpaved access roads usually must be built during the construction phase and some of these may be paved for later permanent use. During the operation phase there will be no major transportation requirements. High-tension transmission lines usually must be constructed, with the length of the corridors depending on the remoteness of the dam from existing transmission lines (EPA 1974).

Several tidal hydroelectric sites have been studied along the eastern Maine coast, adjacent to New Brunswick (NEEC 1978). While the technological development of tidal facilities is somewhat less advanced than that of conventional hydroelectric plants, with only two operating plants in the world, interest has been rekindled in several proposals for developments in eastern Maine and Canada (NOAA 1978). Tidal hydroelectric systems are conceptually similar to fresh water systems although the logistics of operation and economics are more complex. In addition, the impacts of tidal power developments are largely speculative and unknown at this time (although the parameters of potential impacts have been described: see Duff 1978; NEEC 1978; NOAA 1978).

Recent research conducted for the Department of Energy has identified potential sites in Maine and Alaska (Wayne 1979). The Department of Energy currently has let a small contract to the Maine Passamaquoddy Indian tribe to study the feasibility of a small-scale pilot tidal power plant at Half Moon Cove in Cobscook Bay. The U.S. Army Corps of Engineers is also conducting an analysis, scheduled for completion in 1981, of several possible

projects in Cobscook Bay. Because the identified tidal power sites in Maine are under active consideration by federal agencies, tidal power is not specifically discussed further in this alternative.

Economics

The cost per kilowatt of installed capacity for hydroelectric projects in New England averages between $1,000 and $1,200, comparable to the installed cost of thermal plants (ACE 1977; GCHEE 1977). Operation and maintenance costs are usually less than those for thermal plants and fuel is essentially free. In New England, however, hydroelectric plants are more expensive to operate than fossil-fueled plants because they operate far fewer hours per year. This low capacity factor produces high annual costs per unit of power generated. Recent studies indicate that the cost of producing peaking power at hydroelectric stations ranges between 37 and 136 mills per kilowatt hour (ACE 1977). Peaking power currently sells at an average price of 40.8 mills per kilowatt hour on the southern Maine electric power grid (Sherburne 1979). The more cost-efficient hydroelectric stations could produce power at a marginally competitive price.

Environmental Impacts*

Construction impact. For new facilities, land clearing in the area of the reservoirs and the dam structure would increase temperature and turbidity of receiving waters and rate of the runoff. Terrestrial habitat would be permanently destroyed by the inundation of reservoir waters, and existing human-made structures would have to be relocated if they were to be preserved. The downstream aquatic ecosystem would be disrupted due to turbidity, temperature, and erosion; the loss of some species from the system might result. Aesthetic values would decline at least temporarily in the area of the dam and reservoir due to land clearing and construction activities. Economic benefits to the area would increase in proportion to the number of temporary jobs created and distribution of capital expenditures within the locality. Construction impacts associated with renovating existing dams would

* Information on construction, operation, fuel procurement, and transportation impacts all come from EPA 1974.

be similar to those for a new facility but much smaller in magnitude, especially if a reservoir was already established.

Operation impacts. During the filling and subsequent containment of a new reservoir, a new aquatic environment would be created in which there was little turbulent mixing. This causes thermal stratification, the settling of some nutrients, increased algal growth, and decreased dissolved oxygen content. A new ecosystem would be created, which contained organisms adapted to warmer temperatures, slower flow, and lower dissolved oxygen content.

The operation of the hydroelectric facililty might cause nitrogen saturation and change the downstream flow regime, which in turn might stress the life cycles and threaten the survival of certain aquatic organisms. If a fish ladder were not provided, the impoundment would prevent migrating fish from reaching upstream spawning areas. Dam operation would also result in fluctuations in reservoir water levels. This could create an unsightly and biologically nonproductive drawdown zone around the reservoir.

The socioeconomic impacts of maintenance would be minimal, since the facility would require few raw materials and create few jobs. If an existing dam site is redeveloped, operation of the plant might disrupt established human uses of the nonfluctuating stream and reservoir. The air quality and noise impacts of operation would be negligible.

Fuel procurement impacts. Since water is a self-renewing resource, available on site, there would be no major impacts associated with fuel procurement except for those changes in stream flow and water level described above.

Transportation impacts. Transportation impacts would result from a temporary increase in truck traffic during construction.

Relationship to national, state, or local plans and policies. The Public Utilities Regulatory Policy Act of 1978, part of the National Energy Act, encourages the development of existing dams, but not completely new hydroelectric facilities. The state of Maine encourages all economic low-head hydro projects (MOER 1976).

The state of New Hampshire encourages the development of small hydro projects between 50 and 500 kilowatts (New Hampshire Revised Statues Annotated 362:2).

Summary of long-term effects. The long-term impacts of the hydroelectric alternative would depend primarily on the types of facilities chosen. As described in the text, the impacts for new and renovated facilities can be quite different. These impacts include (for new dams):

- permanent removal of supportive habitat for terrestrial organisms in the area of the reservoir,
- creation of a new aquatic environment and ecosystem in the reservoir area due to the impoundment of previously free-flowing waters,
- olfactory and aesthetic problems during periods of reservoir drawdown,
- disruption of homes or businesses located on or adjacent to a reservoir site, and
- possible attraction of secondary development to the area of the facility, including new industries and recreation facilities.

The principal impact of renovating dams is the possible creation of community resistance to water level variation in cases where it disturbs established uses of the abandoned reservoir and changes characteristic downstream flow. Impacts of both kinds of facilities include changes in downstream water quality and aquatic ecosystems due to temperature stratification, decreased oxygen content, nitrogen saturation, and stream flow fluctuation.

5.3.6. Other Fuels

Natural Gas

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a 25-megawatt gas-fired electric generating facility in southern Maine.

Description. The Powerplant and Industrial Fuel Use Act of 1978 specifically prohibits the use of natural gas as a primary energy source in a new major fuel-burning installation. The

definition of a major fuel-burning installation includes a facility with boilers designed to consume fuel at a rate of 100 million or more Btu per hour. A generating facility producing twenty-five megawatts of electricity is well in excess of this threshold, with a fuel consumption capacity on the order of 200 to 300 million Btu per hour. The Act further allows the Secretary of Energy to order the conversion of existing facilities from natural gas or petroleum to coal or other alternative fuels.

Because of these prohibitions, a gas-fired cogenerating facility is not a feasible alternative.

Geothermal

Policy statement. The U.S. Department of Energy could choose to support the development of a 25-megawatt electric generating plant powered by steam that is derived from the natural heat of the earth's interior.

Description. The use of geothermal energy for the production of electricity is not feasible in Maine for the reasons discussed in Section 5.2.7.

Solar

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a 25-megawatt solar electric generating plant in southern Maine. The plant could use photovoltaic cells to convert solar radiation directly into electricity, or it could be a solar-powered steam-electric plant.

Description. Photovoltaic cells consist of differently charged layers of crystals connected by one electrical circuit. When solar radiation passes through the layers, a small electric current is created in the circuit. Individual cells are connected in series to provide direct current. The direct current must then be changed to alternating current in an inverter if it is to be fed into the regional transmission grid. The electric power generated in this way can be stored in a battery for use during nights and cloudy periods (Geary & Jones 1977).

Photovoltaic technology has been successfully demonstrated in small or specialized electrical appliances (e.g., satellites,

two-way radios, remote signaling and meteorological equipment) (Bereny 1977). However, the use of photovoltaics for the production of electricity on a large scale has not been demonstrated and is an unlikely near-term alternative in New England for several reasons:

1. The efficiencies of solar cells are very low. A commercially produced cell can realize an efficiency of about 15 percent with a theoretical maximum of about 23 percent (Geary & Jones 1977). The conversion of direct current to alternating current has a typical efficiency of 85 percent. Thus, total photovoltaic cell efficiencies are about 10 percent if they are used for central-station electricity production. This low efficiency dictates a very large collection field for even small central-station facilities.
2. A central-station photovoltaic plant would require roughly twice the amount of land needed by a solar thermal plant (Geary & Jones 1977; see Section 5.2.8) or nearly one-half of one square kilometer for a 25-megawatt plant in the Southwest. Because solar radiation in New England is less than in the Southwest, the amount of land required would be roughly one square kilometer (Geary & Jones 1977). The requirement for large amounts of flat, open space limits the applicability of large-scale photovoltaics in southern Maine.
3. Sudden changes in insolation (solar radiation) quickly increase or decrease the power output of a photovoltaic plant. Undependability of this nature could cause difficulties for utilities, which require predictable power supplies. This problem can be offset by electric storage systems that have short response times. The only known electric storage technology that would be suitable on a large scale is a super magnetic conducting system (Ruane 1977c). However, such systems are only in the research stages and are not currently available.

For the above reasons, a 25-megawatt photovoltaic electric generating plant is not currently a feasible alternative method of producing electricity in southern Maine.

Wind

Policy Statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a

series of electric generating devices that extract energy from the wind. In combination, the wind-powered generators would add twenty-five megawatts of electric potential to the southern Maine power grid.

Description. The process for converting the kinetic energy of wind into electrical energy is straightforward. The wind acts against some type of blade or propeller connected by a drive shaft to a gearbox and electric generator. There are many different designs for wind energy conversion devices but most have rotors with either a horizontal or vertical axis (Eldridge 1975). Largely for reasons of economy, horizontal designs have been used in the designs for most large-scale electric generating systems (Labuszewski 1977).

Current large-scale wind projects involve designs with rated capacities of several hundred kilowatts. The largest wind-powered turbine in operation in the country today is a Department of Energy pilot 100-kilowatt project in Sandusky, Ohio.

The capacity of a wind-driven generator is limited by the fact that wind is dispersed. The only way to increase the rotor power in large wind-powered generators is to increase the amount of wind intercepted by lengthening the rotor blades. With currently available engineering materials, rotors larger than two-hundred feet in diameter cannot be designed to operate safely (Black 1976).

Because the wind speed is rarely constant, the actual daily and seasonal power output from a wind-driven generator would be highly variable and unpredictable. An array of generators spread out geographically over areas with different wind regimes would mitigate some of this variability. An array of generators throughout southern Maine would always provide some power input, though it would be less than the combined potential of all the generators in the network. In order to compete directly with central power stations, some kind of energy storage system would be required to make wind power feasible (Eldridge 1975). Pumped storage hydro, compressed air, and thermal energy storage are near-term options on a large, utility-size scale (Labuszewski

1977) but only pumped storage is currently commercially available (ACE 1977).

Although wind-powered electric generators are technologically possible, they will require further testing in order to ensure their feasibility on a commercial scale. The Department of Energy has a wind energy program underway. Thus far, only experimental, large-scale demonstration units have been constructed. Multi-unit commercial demonstrations, which would be required for this alternative, are not scheduled until the mid 1980s (ERDA 1976). Mass-produced facilities will probably not be developed until after 2000. Therefore, in view of current development efforts and the level of available technology, a large-scale wind energy project is not a feasible alternative at this time.

Ocean and Tidal River Currents

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a series of small electric generating devices that extract energy from ocean or tidal river currents. In combination, the devices would supply an additional twenty-five megawatts of electric power to southern Maine.

Description.* The force of moving water in river and ocean currents is a potential source of usable energy. Off the coast of Maine, nontidal ocean currents are very weak. The strongest ocean current, in the Gulf of Maine, flows at only .2 knots, which results in a power density of only .57 watts per square meter. However, currents in some tidal rivers and narrow inlets along the Maine coast have enough kinetic energy to drive turbines, paddle-wheels, or rotors. Power densities between one and five kilowatts per square meter have been estimated for some sites in Maine.

There are two devices that have been designed to extract energy in the form of electricity from currents: the screw turbine and the Savonius rotor. These devices rely on drag or lift forces of the moving water to rotate a drive shaft or turbine, which is connected to an electric generator. The process is very similar to that employed in wind-powered generators. The efficiencies of these devices can range between 30 and 45 percent. As with wind

* Source: Mays 1977b.

power generators, the direct current must be converted to alternating current, resulting in a decrease in overall system efficiency. Hydroelectric plants located in dammed tidal rivers are another way to use the force of tidal currents. However, these plants operate on the same principle as conventional hydroelectric plants and therefore will not be discussed here.

The problems associated with tidal current energy conversion devices are similar to those of wind machines. In addition, they must be capable of operating when the water flows in alternate directions as the tide floods and ebbs. The systems are also subject to periodic increases and decreases in power production as currents change, although the variability is predictable and less severe than it is for wind-powered systems. Weathering and, especially, corrosion are problems that require further design consideration.

Generally, tidal current energy systems are technically feasible, although no large-scale projects have yet been implemented. Because of the periodicity and relatively small power densities of available flows, these energy systems cannot supply base-load power. The systems will have to be operated as "fuel savers," helping to reduce the amount of fossil fuels used. If large-scale electrical storage systems were available, then the power produced by tidal current energy devices could provide an additional twenty-five megawatts, but no such systems suitable for utility use have been developed as yet. For these reasons, tidal current energy does not represent a currently feasible alternative method of creating additional electricity for southern Maine.

Wave Energy

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of devices that convert the kinetic energy of waves into electricity. A combination of these devices would supply twenty-five megawatts to southern Maine.

Description.* Wave energy extraction devices rely on the kinetic energy of waves to drive pumps, flywheels, compressors, and turbines. The mechanical energy imparted to this machinery is transferred to an electric generator. Although no large-scale wave conversion systems have ever been implemented, there have been many designs proposed. Three designs currently receive the most attention from researchers:

1. Wave power absorbers rely on the oscillating motions of tethered rafts floating on the ocean surface to power a hydraulic system connecting the rafts. The pressurized working fluid drives a turbine-generator.

2. Buoy-shaped turbine generators use the "heave" or up-and-down motion of waves, to move a piston. The piston pressurizes a working fluid, which drives a turbine-generator.

3. Salter cams depend on the oscillation of waves to swing a pendulum-type device (cam) within a buoy. The cams drive rotary pumps which are connected via hydraulic motors to electric generators.

Wave energy is a renewable energy source with no apparent major technological barriers to its development. However, the design experience is extremely limited and unproven and there is a general lack of reliable wave data off the Maine coast. Indeed, the principal problems with wave energy conversion for Maine stem from the wide daily and seasonal variability in wave action. This variability requires a conversion system that will function in a wide range of ocean conditions. Such systems have not been developed except on an experimental basis. For this reason, wave energy is not currently a feasible alternative method of producing twenty-five megawatts of electricity in southern Maine.

Ocean Thermal

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of ocean thermal energy conversion plants to supply twenty-five

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* Source: Mays 1977a.

megawatts of electric power to southern Maine.

Description.* Ocean thermal energy conversion power plants are heat engines that use the temperature differential between the surface waters and deep ocean layers to evaporate and condense a working fluid that has a low boiling point (e.g., ammonia or freon). The fluid is vaporized in the warm upper layers and drives a turbine electrical generator. The fluid is condensed in the cool bottom layers and then pumped again to the surface. The plant is anchored in the ocean and electricity is transmitted via an underwater cable to shore.

Ocean thermal plants have low efficiencies (between 2.5 and 3.0 percent) because the temperature gradient is small and the volume of water that must be processed is very large. The technology for these plants is still in the research stage and has not been demonstrated on a large scale. In particular, fabrication and maintenance problems associated with the evaporator and condenser have not yet been solved, although the Department of Energy is planning to begin testing an ocean thermal plant in 1986.

Ocean thermal plants would not be feasible off the Maine coast due to the small differential between surface and deep water temperatures.

Nuclear

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a 25-megawatt nuclear power plant in southern Maine.

Description. Nuclear steam cycle plants use the heat released by the fission of uranium atoms to create steam. The steam is used to drive a turbine-generator. The total cost of a small nuclear plant is not proportionately less than that of a large one, due to the substantial investments required for safety, support facilities, back-up systems, waste disposal, and other features. For this reason, it is uneconomical to construct small nuclear plants. There are no nuclear power plants under construction in the United States that are smaller than 527 megawatts (Nuclear Industry 1979). Therefore, it would not be feasible to build a nuclear plant of only 25-megawatt capacity.

* From Ruane 1977b.

The purchase of a 25-megawatt block of power from a nuclear power plant would result in an increment of environmental impacts of that facility. Analysis of these impacts is beyond the scope of this study. (For a full discussion of these impacts, see AEC 1974.)

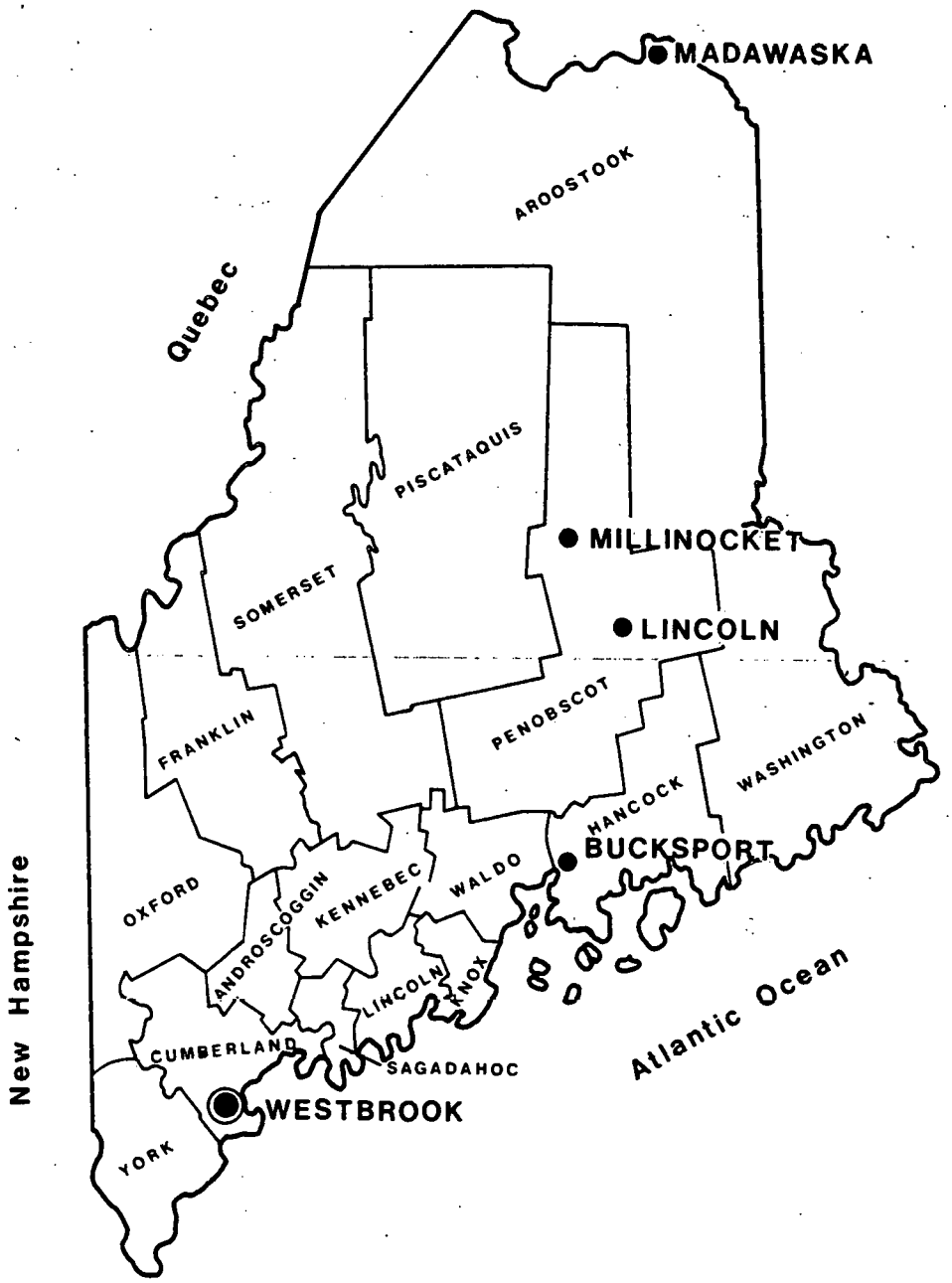
5.4 ALTERNATIVE SITES

5.4.1 Process of Site Selection

To ensure selection of a site that would best meet all criteria for location of a wood-fired power plant, the Department of Energy's contractor (Rust Engineering Company for Wheelabrator Cleanfuels Corporation) assessed locations in the three northern New England states. On the basis of the relative abundance of low-quality wood and wood residue in Maine, this state was chosen for detailed investigation. Twenty-two sites in Maine, each adjacent to a large-scale industrial steam customer, were assessed. These locations were analyzed to ensure that the maximum energy-conserving benefits of cogeneration could be obtained. Of these sites, five were selected on the basis of engineering and economic potential for final evaluation.

The sites selected for final assessment were Madawaska, in Aroostook County; East Millinocket, in Penobscot County; Lincoln, in Penobscot County; Bucksport, in Penobscot County; and Westbrook, in Cumberland County (see Figure 5.4.1-A). Westbrook, the site finally selected, is the subject of this environmental report; the evaluation of the four alternative sites follows. The plant specifications for the alternative sites are assumed to be the same as those for the Westbrook site; however, because the cogeneration requirements differ at each site, the actual plant specifications would probably differ slightly. The environmental impacts of the proposed plant at the alternative sites are described here only to the extent that they differ from those at the Westbrook site. Otherwise, the impacts may be assumed to be similar.

FIGURE 5.4.1-A: FIVE MAINE SITES EVALUATED AS LOCATIONS FOR WOOD-FIRED POWER PLANT



5.4.2 Characteristics of Alternative Sites

Madawaska

Site. The power plant site considered (see Appendix J) is adjacent to Fraser Paper Limited's American paper mill, which would be the steam customer. The site is bounded by the St. John River, U. S. Route 1, and Bridge Street in Madawaska. Truck access to the plant would be from Mill and Bridge Streets. Electric and steam transmission lines could be contained on the property.

The acreage at the site is sufficient only for the power plant buildings, so additional land would have to be acquired along the valley close to Route 1 for a chip storage area. Much of the suitable land close to Route 1 and the railroad is flood-prone and zoned for resource protection.

Use of power by customer. Fraser Paper Limited has stated that it would use the proposed plant to replace existing oil-fired boilers that it presently operates (Hale 1978).

Transportation and traffic. From harvesting areas in Maine, chip vans would haul fuelwood to the plant on Route 1, the only major highway into Madawaska from other parts of the state. Route 1, which is also Main Street in Madawaska, currently suffers from significant congestion, which would be made worse by the trucks carrying fuel for the plant. If significant quantities of wood were supplied from Canada, severe congestion would also result at the only border crossing, the International Bridge.

Air quality. Madawaska and the proposed plant site are situated deep in the valley of the St. John River, which flows from west to east. The valley lies approximately five hundred feet below the mountains to the south, has moderately steep slopes, and often has poor air dispersion characteristics (see Appendix J). Recent measurement of the ambient particulate pollution levels indicated a number of violations of the state's 24-hour particulate standard (see Appendix J), although this may be partly attributed to fugitive dust.

The current occurrence of some violations, a high background particulate level, and the probability of poor dispersion with plume impact on the valley wall indicate that a wood-fired power plant at this site could pose an air quality problem. The substitution of a wood-fired power plant for the present oil-burning facility, however, would reduce sulfur dioxide concentrations in the air.

Water availability and water quality. The water source for the plant would be the St. John River, which at Fort Kent, approximately twenty-two miles upriver from Madawaska, has a mean discharge of 9,961 cubic feet per second (cfs), and a recorded low flow of 596 cfs based on ten years of records (USGS 1967-1977). The plant's water requirements (see Section 3.2.2) would represent 5 percent of the St. John's low flow, which indicates that the water supply is adequate. In any case, the plant would be replacing an existing oil-fired facility, which currently draws comparable amounts from the river. Cooling towers or ponds would ensure that the state water temperature standards could be met. Impacts of water effluent are expected to be less severe than those of the current facility.

Landfill availability. A 75-acre state-approved landfill site operated by the town of Madawaska is available sixteen miles from the site.

Zoning. The probable power plant location on the Fraser Paper Company property is zoned for industry. The wood storage area has not been specified, but there is a shortage of suitable land zoned for industrial use in the area near the Fraser site. Much of the undeveloped land along the St. John has been zoned for resource protection as flood plain land.

Socioeconomic impacts. Madawaska had an average labor force of 2,308 in the period from March of 1978 to January of 1979, with 151 persons unemployed (MDMA 1979). Because the local labor force is so small, most of the 240 workers needed for construction (see Section 3.1.6) would come from outside the immediate area. This temporary increase in population would tighten local housing markets and strain retail and community services. Some impact would also be felt in the Canadian town of Edmunston.

School enrollments declined from a peak of 1,929 in 1970 to 1,681 in the 1977-1978 school year (Houghton 1979); consequently, the town would be able to cope with the increased school population.

The labor force of about thirty-two workers needed to run the facility (see Section 3.2.7) would probably be composed of those who had run the oil boilers at Fraser Paper Limited. No net change in local employment or expenditures would be expected to result from the operation of the new boiler and no change in indirect employment or income would occur (see Section 3.2.7).

The socioeconomic impact of harvesting operations would almost certainly spread into Canada. The effects in Canada would be proportional to the amount of wood brought from that country and would include the employment of Canadian harvesters and truckers and the generation of indirect income and employment. In addition, it is likely that some of the woods workers in Maine would also be Canadian. Hence the direct and indirect socioeconomic benefits resulting from harvesting (see Section 3.3.10), such as jobs, tax revenue, and income, would be smaller for the state of Maine than if the plant were not located near Canada; costs such as social services and road maintenance, however, would be somewhat reduced if the plant were in Madawaska.

Fuelwood supply impacts. Although the fuelwood harvesting areas for a plant in Madawaska have not been identified in detail, the supply from Maine would come mainly from the west and southwest of Madawaska, as the area to the south and southeast is dominated by agriculture. The harvesting impacts in this area would probably not be significantly different from those in the Millinocket, Lincoln, or Bucksport regions, although over half of the area within a fifty-mile radius of the proposed Madawaska site lies in Canada. The established pulpwood supply areas for the Edmunston-Madawaska mill complex are mainly in Canada.

The forests of northern Maine are dominated by spruce/fir stands, which are under increasing pressure for pulpwood production. The forest lands are mainly held in very large ownerships

by companies involved in commercial sawlog and pulpwood production. Within the spruce/fir stands are smaller but significant quantities of northern hardwoods, which at present are mainly of poor quality and of much less economic value to the pulp and paper industry than the spruce and fir. Harvesting wood for energy production would almost certainly take place in both of these forest types and might involve integrated operations with pulp and timber harvesting which would lead to more complete utilization of the wood from existing logging operations. In the spruce/fir forests, even-age management and clearcutting are frequently the preferred management practice for pulpwood production.

The impacts of harvesting fuelwood in these areas will depend on the management practices adopted. It seems likely that the creation of a new market for low-quality wood of any type will result in increased clearcutting as part of a management strategy to convert hardwood stands to spruce, thus accelerating the use of even-age management and the cultivation of single-species stands. In some instances, the market for low-quality wood created by this project could also stimulate timber stand improvement in both hardwood and softwood stands. With both clearcutting and timber stand improvement operations, increased mechanization and more complete wood removal from the forest would ensue. Improperly conducted, both techniques could also lead to soil erosion, large volumes of water runoff, severe water quality impacts, and aesthetic deterioration. These impacts are typically more adverse with clearcutting procedures, though well-designed harvest operations minimize their severity (see Section 3.3).

Potential harvesting impacts in Canada have not been assessed; however, it is probable that they would be generally similar to those in Maine.

Large supplies of bark and wood residue are available in the area, and their use in this plant would reduce current landfill problems and the use of open bark burners (cone burners), which cause high levels of particulate pollution (see Section 3.4).

Summary. Site suitability and the necessity of finding additional land for chip storage present environmental problems at Madawaska. Air pollution, in view of the poor dispersion characteristics of the valley, could also pose a problem. Traffic congestion on Route 1, across the International Bridge, and in Edmunston could be sufficiently serious to cause public concern.

East Millinocket

Site. The site considered would be adjacent to the Great Northern Paper Company Mill #2 in East Millinocket (see Appendix J). The site is bounded by Route 11 and the West Branch of the Penobscot, and is at present used as a parking lot. Minor rerouting of private plant driveways and relocation of another small parking lot would be necessary to accommodate the proposed plant, although no demolition of buildings would be required. At present there is no vegetation on the site, which is used entirely for industrial purposes. Wood chip fuel would be stored at the northern end of the Great Northern yard in an area currently used for cordwood storage. Access to the chip storage area would be from Main Street (Route 11), via the present plant entrance (Mill Road). Steam and electric power lines could be contained on the Great Northern site.

Use of power by customer. Great Northern has indicated that it would use the steam and electric power generated by the plant to replace existing oil-fired boilers that they currently operate (Reardon 1978).

Transportation and traffic. Fuelwood would arrive at the plant from all directions: from the west on Route 11, the north and south on Interstate 95 via Route 11, and the east on Route 157. All traffic would converge on Main Street (Routes 11 and 157) for access to the plant site. The town of East Millinocket is situated primarily to the north of Route 11, and therefore would not be significantly affected by trucks traveling to the plant. The only area where serious traffic problems might occur is in the town of Millinocket, where traffic from the private haul road of Great Northern Paper is routed through the center of town on Route 15. This route, however, would probably accommodate no

more than one-quarter of the total truck traffic, depending on harvesting plans.

Air quality. Air Quality Region 109 and East Millinocket are legal attainment areas for particulates, sulfur dioxide, carbon monoxide, and nitrogen oxides, but exceed primary standards for ozone. The generally open topography of the Penobscot Valley at East Millinocket provides good air dispersion. The substitution of wood for oil as an energy source would reduce currently high ambient sulfur dioxide levels although it would increase particulate pollution.

Water availability and water quality. The water source for this site is the West Branch of the Penobscot River, the flow of which is controlled year-round by an extensive series of upstream dams owned and operated by Great Northern. The average daily flow is 2,800 to 2,900 cfs (Welch 1978). As the river is carefully controlled, the flow seldom drops below this level.

The wood-fired power plant's water requirements equal about 1 percent of the estimated low flow (see Section 3.2.2). As the wood-fired power plant will replace existing oil-fired boilers of roughly the same capacity, no significant additional drain on the waters of the West Branch will occur. Use of cooling towers or ponds would ensure that water temperature standards were met.

Landfill availability. A state-licensed landfill owned by Great Northern is available two miles from this site.

Zoning. The site is zoned for industry.

Socioeconomic impacts. The impacts on the local community would be shared by the towns of East Millinocket and Millinocket, both of which have experienced substantial construction activity in recent years. The labor force in East Millinocket averaged 1,021 during the period from March of 1978 to January of 1979 with 51 persons unemployed (MDMA 1979). The 240 construction workers needed for the facility would, for the most part, have to come from other areas of the state.

A temporary increase in population would create a temporary strain on housing and existing community services. Educational services should be least affected since schools experienced

enrollments declining from 1,444 in 1970 to 1,325 in 1978 (Savage 1979).

Most of the positions created by operation of the proposed wood facility would be filled by workers who had previously run oil boilers at Great Northern. No net change in local employment or expenditures would be expected to result from the operation of the new boiler and no change in indirect income or employment will occur (see Section 3.2.7). There are over 350 logging firms within a fifty-mile radius of East Millinocket (MDC undated). Some of the harvesters needed for this plant's operation would be unemployed persons in the area; others would be Canadian bonded or visa workers; others would be persons presently in other occupations, especially heavy equipment operators. Any immigration to fill these positions would be dispersed over a wide area (over 7,800 square miles) and would have a minimal impact on population. Indirectly created jobs should also be primarily filled by persons in the area, as would the jobs in trucking (see Section 3.3.10).

Fuelwood supply impacts. East Millinocket lies in the middle of the Northeast's largest forested region, an area dominated by spruce/fir forests and consisting almost entirely of large landownerships held by companies interested in marketing timber products. Currently, no significant market exists for low-grade hardwood produced in this region. The impacts of harvesting in this region would be generally similar to those described for Madawaska except it is not expected that wood would be harvested in Canada. Large amounts of bark and wood residue are available in this region; their use would constitute an important environmental benefit by alleviating the need for landfills and open cone burners (see Section 3.4).

Summary. Impacts associated with the operation of and harvesting for a plant in East Millinocket would be relatively minor. Some traffic congestion could occur in Millinocket from the transportation of fuelwood through that town. Construction impacts could be somewhat disruptive and cause a temporary housing shortage and boom-town atmosphere.

Lincoln

Site. The site considered would be located on the property of Lincoln Pulp and Paper Company, the potential steam customer, between Lincoln Village and the Penobscot River. Although the proposed location of the power plant would probably be close to the pulp mill, the exact sites for the boiler and chip storage piles have not been specified. Access to the site by road would probably be through existing entrances on Depot Street and on an access road off West Broadway (Route 2). Transmission lines for steam and electric power would be contained on the property of the Lincoln Pulp and Paper Company.

Use of power by customer. The Lincoln Pulp and Paper Company would use the power from the facility for an expansion of its pulp and paper-making operations. It would not shut down existing boilers.

Transportation and traffic. Lincoln is centrally located in a major forested area; wood supplies are expected to come from all directions. Fuelwood would arrive along Route 2 from the north and south with connections to Interstate 95, and Route 6 from the east and west. Truck traffic converging on Lincoln would cause problems at a number of points (see Appendix J). In many cases, these problems could be greatly reduced by minor road realignments, some of which are currently in progress. Truck routes that avoided Main Street would ease traffic congestion.

Air quality. The topography surrounding the Lincoln site is gently rolling and air dispersion appears to be moderately good. The Maine Department of Environmental Protection has classified Lincoln as an attainment area for sulfur dioxide, nitrogen oxides, total suspended particulates, and carbon monoxide, and as a non-attainment area for ozone (MBAQC 1978). Particulate air pollution is a problem in Lincoln, as Maine's 24-hour standard has been exceeded on at least fifteen occasions since 1973. The proposed plant would increase particulate emissions to the region's air.

Water availability and water quality. There are two potential sources of water at the Lincoln site: the mill pond on the Mattanawcook Stream and the Penobscot River. The mill pond is the

present source of water for the Lincoln Pulp and Paper Company mill. The mean discharge of the Penobscot based on data from Mattawamkeag is 6,160 cfs, and the recorded low flow is 2,000 cfs (USGS 1967-1977). The wood-fired power plant's water requirements (see Section 3.2.2) would represent 2.2 percent of the recorded low flow. On this basis, an adequate supply of water is available. Cooling ponds or towers would ensure that the temperature standard was met at this site. Plant effluents would add to present discharges.

Landfill availability. There is a landfill on the Lincoln Pulp and Paper Company site, but it is close to capacity (Linnell 1978) so another site would have to be found. There is no site available in the town of Lincoln at present, and a recent study showed that the closest possible site that meets state standards is in Hampden, over fifty miles away (LCC 1978).

Zoning. The proposed site is zoned for industry.

Socioeconomic impacts. Lincoln had an average labor force of 1,997 during the period from March of 1978 to January of 1979, with 126 persons unemployed (MDMA 1979). Most of the 240 construction workers would have to come from other parts of the state. This temporary increase in population would create some stress on housing and local services, although Lincoln has experienced large construction operations in the recent past without serious problems. Lincoln would be able to accommodate increased school requirements because enrollments have declined from 1,678 pupils in 1970 to 1,613 in 1978. They are estimated to have dropped to 1,598 by 1979 (Webster 1979).

The persons required to run the wood boiler would be newly hired. It is likely that most would come from the Lincoln-Howell labor area, as would the small number of indirectly employed persons.

The socioeconomic impacts of harvesting would probably be similar to those described for East Millinocket.

Fuelwood supply impacts. Lincoln lies in the middle of the Northeast's largest forested area. It is a region primarily of large landownerships held by companies interested in marketing

timber products. Currently, no significant market exists for low-grade hardwood produced in this region. A large quantity of bark and wood residues is available in this area; its use would constitute an important environmental benefit by alleviating the need for landfills and cone burners (see Section 3.4).

Summary. The major impacts at Lincoln would be air quality impacts, trucking impacts, and socioeconomic impacts during construction.

Bucksport

Site. A site for the wood-fired power plant has not been specified; it would probably be less than one and one-half miles north or northwest of the St. Regis Paper Company mill, the proposed steam customer (see Appendix J). As the site has not been chosen, the site characteristics cannot be assessed. The only undeveloped land within one and one-half miles of the paper mill is north of the plant and to the east of Route 15. This area is gently sloping and partly wooded. Several small residential developments and an oil tank farm close to Route 15 occupy adjacent sites. Depending on the choice of site, rights of way or easements for the steam and electric transmission lines would be required. These might have to pass through residential areas and the tank farm, crossing Route 15 and the Maine Central railroad tracks.

Use of power by steam customer. The St. Regis Paper Company has indicated that it would use the steam from the proposed plant to replace existing oil-fired boilers and the electricity to replace electric power purchased from Central Maine Power Company.

Transportation and traffic. The wood supply areas for the proposed plant would be generally similar to those from which the St. Regis Paper Company obtains its pulpwood. Currently, most cordwood arrives in Bucksport via Route 1 from Washington and Hancock counties. Some additional wood for a wood-fired facility in Bucksport would undoubtedly come as residues or low-quality hardwood via Route 15 from north of the Bangor area. All chip vans arriving from eastern Maine and most arriving from western

Maine would reach the probable Bucksport site by traveling westbound on Main Street through the village of Bucksport.

This narrow, small-town, commercial main street is severely congested during the summer months when tourists frequent the village, and is moderately congested during the "off-season" (Lowell 1978). The intersection of U.S. Route 1 and Route 15, where the only major supermarket in Bucksport is located, also experiences serious congestion and traffic delays. Additional truck traffic associated with the proposed project would increase this congestion and could require a by-pass road. The impact of chip vans from Bangor and Brewer on Route 15, a narrow road that winds through several small towns, could also be adverse.

Air quality. The probable site at Bucksport is near the bottom of a moderately steep-sided valley, three to five hundred feet deep, that runs north to south. The dispersion characteristics are less than ideal. Examination of the ambient particulate and sulfur dioxide data indicates that an air pollution problem already exists in the Bucksport area (see Appendix J). There have been several violations of the state particulate and sulfur dioxide standards during the past two years. Although conditions have improved, especially for sulfur dioxide, since the completion of the St. Regis' tall stack in June of 1976, there have nevertheless been eight violations of the state 24-hour particulate standard since that date. Although some of these incidents might be attributable to fugitive dust, their occurrence at several sites and the generally high background levels indicate a problem.

Uncertainty with respect to how much oil-fired capacity would be closed down in proportion to the new facility's output makes it difficult to determine the extent of likely air-quality tradeoffs. Some reductions in sulfur dioxide levels could be expected with the shutdown of the oil boilers, but net particulate emissions would increase. The proximity of elevated terrain nearby increases the possibility of localized air quality standard violations resulting from the impact of the plant's plume.

A plant in Bucksport, depending on construction schedules, might have to compete for the allowable regional particulate increment with a large coal-fired power plant planned for Sears Island by Central Maine Power Company. A major hydrocarbon source, such as a wood-burning plant, located in the vicinity of a large nitrogen oxide source, such as the Sears Island coal-fired power plant, could cause ozone formation where the plumes intersect.

Water availability and water quality. The St. Regis Paper Company mill uses water from Silver Lake, which is approximately three-quarters of a mile north of the plant. The lake could provide at least 20 million gallons per day; at present only 15 to 16 million gallons are used for boiler feed (Robinson 1978). The lake also supplies Bucksport's domestic water. The proposed plant could probably draw the 1.8 million gallons per day it needs from this source (see Section 3.2.2).

If cooling towers were used, thermal impact would be minimal.

Landfill availability. There are no suitable landfill sites in the Bucksport area. The St. Regis landfill is close to capacity, and the town of Bucksport, after searching for a closer site, now trucks its solid waste twenty miles to Hampden near Bangor.

Zoning. The town of Bucksport does not have zoning ordinances except for state mandatory shoreland zoning. Unless the plant were to be located on the waterfront, zoning would not apply.

Socioeconomic impacts. Bucksport is seventeen miles from the Bangor-Brewer area and twenty miles from the Ellsworth area. The average labor force in Bucksport during the period from March of 1978 to January of 1979 was 2,028, with 89 persons unemployed (MDMA 1979). Additional workers could commute from the Bangor-Brewer and Ellsworth areas. The influx of construction workers would be absorbed by these communities as well as by Bucksport. Consequently, only modest strain on housing and community services in the town would be expected. School enrollments have declined very slightly in recent years (Kinney 1979).

Most of the workers needed to run the facility would be the people who ran the oil boilers it replaced. The number of those indirectly employed would be small and should come from the immediate area.

The socioeconomic impacts associated with harvesting fuelwood for the plant at this site would be similar to those discussed for East Millinocket and Lincoln.

Fuelwood supply impacts. The area likely to be the major fuelwood supply area for a wood-fired power plant at Bucksport lies to the east and northeast of the town. It is a region composed primarily of large landownerships held by companies interested in marketing timber products. Currently, no significant market exists for low-grade hardwood produced in this region. The harvesting impacts for Bucksport would be expected to be generally similar to those described for East Millinocket and Lincoln.

The proportion of hardwoods in the Hancock county area is higher than in the harvest areas for the other alternative sites. Landowners in the area are poisoning hardwoods at present to convert the forests to the more profitable spruce/fir type. The opening of a market for low-grade hardwoods would enable landowners to sell these hardwoods and could hasten the transition to spruce/fir forest. Large amounts of bark and wood residue are available in this area; their use could constitute an important environmental benefit by alleviating the need for landfills and cone burning (see Section 3.4).

Summary. Construction of the proposed plant at Bucksport would require the acquisition and development of a currently undisturbed site. In addition, steam and electric power transmission lines from the proposed plant to the steam and electric customers would involve the acquisition and development of right-of-ways. Truck traffic congestion, air pollution, and the lack of suitable landfill sites are other environmental problems that would be encountered at Bucksport.

5.5 ALTERNATIVE USES OF WOOD

5.5.1 Use of Wood for Space Heat

Domestic Space Heat

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the use of wood for home space and water heating.

Description. The Department of Energy could stimulate the use for home heating of the approximately 680,000 tons of wood that would have to be harvested each year to fuel the proposed cogenerating facility. Assuming an average annual consumption of twelve tons (five cords) per household, 57,000 households in Maine could be heated with this wood. A statewide savings of roughly one million barrels of imported oil could be realized if the wood were used for this purpose.

The Department of Energy could adopt a number of approaches to stimulate the use of wood for domestic space heating. Programs for landowners and firewood producers could improve supply reliability and increase quantities of fuelwood on the market. Educational programs for landowners would inform them of the advantages of having low-quality wood removed from their forests and instruct them in the negotiation of economically and environmentally sound contracts with harvesters to accomplish this. Similarly, programs providing assistance in and incentives for long-term planned management of forest lands could encourage landowners to thin and maintain their woodlots, which would also bring a steady stream of low-quality wood into the energy market.

To aid loggers, steps could be taken to improve the economics of cutting and selling fuelwood for domestic use. Support of research and development of small-scale harvesting equipment, combined with a tax incentive program for harvesters acquiring such machinery for fuelwood production, could reduce loggers' operating costs and increase the amount of reasonably priced fuelwood available to the consumer. Likewise, educational programs to assist loggers in improving the quality and efficiency of their harvesting operations could increase the land base available for cutting

and reduce logging costs.

Federal programs could also be devised to stimulate homeowners and tenants to use wood-burning appliances for space heating. A tax incentive program to reduce the financial burden of conversion to wood heating could increase the use of fuelwood. Increased federal support for the design of more convenient and less expensive wood appliances would also help. An educational program on the safe installation and operation of home wood-burning systems could increase homeowner willingness to convert to wood.

Projects demonstrating more efficient wood marketing systems could also encourage the use of wood for domestic space heat. Consumer skepticism about supply reliability and logger uncertainty about market stability could both be relieved through the establishment of centralized distribution and processing centers, or fuelwood marketing cooperatives.

Economics. The most significant economic impact from this alternative would result from the replacement in Maine of roughly one million barrels of imported oil by 680,000 tons of locally produced wood. At most, four cents per gallon of heating oil now sold goes into the regional economy (see Appendix E) or about $1.6 million annually for the oil that would be replaced by this fuelwood. Conservatively assuming a price of $21 per ton for domestic fuelwood, approximately $14 million of revenue would be generated from the sale of 680,000 tons of wood; most of this revenue would go into the regional economy.

A regional education program to introduce forest landowners to the benefits of fuelwood extraction for forest improvement would cost between $100,000 and $200,000 to reach two to three thousand landowners (Swain 1979; Turner 1979). A regional assistance program to help landowners implement plans that take advantage of the fuelwood market would cost approximately $170,000 to reach two thousand landowners per year.

A $50,000 program of educational and demonstration sessions could probably reach most interested logging operators in the fuelwood harvest region. Additional funds would be required for time and motion studies to help harvesters improve the efficiency

of on-the-ground harvest operations.

An average wood stove costs between $300 and $400; installation and chimney improvement can double or triple this price. The cost of 57,000 woodstoves at $350 each would be $19,950,000. If taxpayers (average 30 percent tax bracket) were allowed to deduct the price of the stove only, the federal treasury could lose $5,985,000. This loss would be balanced by the revenue gained by the purchase of domestic, rather than imported, fuel.

An analysis of the costs of research and development programs for improved harvesting equipment and home wood appliances is beyond the scope of this study.

Environmental impacts.

- Construction. The installation of home stoves or furnaces involves little construction; chimney building or repair is the major alteration. Neither air and water quality nor any ecosystem would be significantly affected by the installation of wood stoves. Local business would benefit from increased stove sales.
- Operation. There are no federal or state regulations that control air emissions from residential heating units. Thus, the operation of wood stoves could deteriorate air quality, especially in communities where they are extensively used. Particulate emissions from stoves depend more on the characteristics of operation than on the design of the stove. More research is needed on the relationship between emissions and stove design, wood type, and operating mode (Butcher & Buckley 1977).

Using Butcher and Buckley's (1977) emission factors, burning 680,000 tons of wood in stoves would create between 693 and 6,800 tons of particulates per year. In addition, approximately 88,400 tons of carbon monoxide would be released into the air (EPA 1978). These emissions would be significant if concentrated in an urban area. The dispersion of home woodburning in rural areas where other emissions are low would tend to lessen air quality problems.

Ash disposal could be a problem for landfill areas. However, the use of ash in driveways to prevent skidding and on gardens as a soil conditioner would reduce disposal problems. More chimney fires may result from increased woodburning. This could be

mitigated somewhat by public education on the safe installation and operation of stoves. Local hardware stores will probably benefit from increased stove use in the sale of wood-handling tools and stove accessories. Increased stove use may increase the price of pulp and fuel chips if competition for stumpage or labor arises (see Section 3.3.9).

- Procurement. Firewood procurement will continue to be in large part a by-product of other harvesting operations. Whole-tree chipping will not be used to harvest domestic fuel until a home chip burner is commercially available. The use of traditional harvesting techniques for firewood offers the opportunity to improve forest growth, as does whole-tree harvesting. Nutrient losses may be less with the merchantable bole harvesting method (see Section 3.3.3). On the other hand, uncontrolled expansion of firewood cutting could threaten the resource with overcutting, mismanagement, or erosion. Because per acre yields are lower with traditional harvesting than with whole-tree chipping, more acres may be affected by firewood harvesting than by cutting the same amount of wood to fuel a cogenerating facility.

- Transportation. Transportation impacts would be minimal, because there would be no central harvest or delivery area for the firewood.

- Relationship to national, state, or local plans and policies. The use of wood for home heating is encouraged by the Maine Comprehensive Energy Plan (MOER 1976) and the Goals and Objectives report (Threshold 1977) of the Threshold to Maine Resource Conservation and Development Project. The projects for fuelwood harvesting, marketing, and burning outlined in these plans would be complemented by this alternative.

- Summary of long-term impacts. Increased use of fuelwood for domestic space heating raises concern for air quality in residential areas. If wood replaced oil as a fuel, sulfur emissions would be reduced but particulates and hydrocarbon emissions would increase. Home fuelwood use would make oil available for use in installations incapable of burning solid fuels. In addition, money that now leaves the country would accumulate in the local economy.

Impacts on the forest resource are of primary concern. Uncontrolled firewood harvest could threaten the resource with nutrient losses, erosion, overcutting, and mismanagement. The acreage affected by the harvest of 680,000 tons for firewood will be greater than that disturbed by harvesting the same amount with whole-tree techniques to fuel the proposed facility.

Commercial and Industrial Space Heat

Policy statement. As an alternative to the proposed action, the U.S. Department of Energy could support the use of wood for commercial and industrial space heating.

Description. The proposed cogenerating facility will use approximately 680,000 tons of wood per year. This wood could instead be used for space heating in industries, apartment buildings, motels, greenhouses, shopping centers, and other commercial and industrial establishments. Businesses using wood fuel should be somewhat buffered from rising costs of fossil fuels and the uncertainty of fossil fuel supplies.

The fuelstock for commercial or industrial wood-burning units is wood chips or preprocessed, densified wood pellets. Wood residue from manufacturing processes can also be burned, however. As with domestic firewood, marketing and delivery systems for such fuels are not fully developed.

The Department of Energy could attempt to stimulate the market for commercial wood fuel by assisting the establishment of wood chip dealerships. At present, potential consumers of chips are hesitant to invest in combustion equipment without an assured fuel supply; wood suppliers are skeptical about market opportunities and are reluctant to invest in chipping equipment. Support for a concentration yard for chips from several suppliers might be part of the solution to these problems.

Wood fuel has low density, irregular size, high moisture content, and a tendency to bridge in handling; these characteristics favor its use close to the point of origin, particularly by wood industries that have equipment for, and experience in, wood handling. Even for these firms, transporting, unloading, sizing, preparing, storing, retrieving, and metering wood fuel may be as

important as boiler technology in determining the economic viability of conversion (Hoff 1976). The Department of Energy could stimulate wood fuel use by research, development, and demonstration of handling systems for small industrial and commercial wood energy systems.

Small firms may be unable to afford the capital investment in new burners and pollution control equipment. The Energy Tax Act of 1978 is meant to alleviate the financial burden of conversion to "new" energy technologies by providing a business investment credit. Technical assistance for small companies, supported by the Department of Energy, would further encourage conversion. Many firms need technical, economic, and environmental information to help them assess conversion to wood fuel and to assist them in choosing a system suited to their circumstances.

Gasification may be the best alternative for retrofitting existing gas- and oil-fired boilers. For larger boilers multiple gasifiers can be used. Gasification was used prior to World War II; however, certain problems in the design of the grate and the gas burner and in vessel construction require process improvements (Voss 1977). The Department of Energy could support research and development efforts to solve these problems.

Densified biomass fuel (wood pellets) has some advantages over chips; it is more uniform in size, shape, and moisture content and has better burning properties than do green chips. The higher Btu content per pound and per unit volume lowers the transportation costs per Btu. For industry there is the question of whether the added processing costs are justified by easier handling and improved burning efficiencies (Zerbe 1978). Since moisture content is the key variable in combustion efficiency, the lower moisture content of pellets means lower capital expenditures because less capacity is required to produce the same output. Emission control savings are also achieved with drier fuels (USFS 1976). The technology for pellet use to replace or supplement coal is available (Reed & Bryant 1978). In addition, pellets can be used in gasification and have potential use for home heating. The Department of Energy could attempt to encourage the development of this fuel by financial and/or technical support for pilot demonstration facilities.

Economics. The most significant economic benefit of this alternative derives from the replacement of fossil fuels by wood fuel. If gasifier efficiency is 90 percent (Voss 1977), 4.9×10^{12} Btu could be provided by the use of 680,000 tons of wood for commercial and industrial fuel. This is equivalent to about 34 million gallons of oil. Revenue generated by harvesting, processing, and selling the wood would accrue to the region, rather than to foreign oil-producing nations. In addition, businesses using wood fuel should be somewhat insulated from rising fossil fuel costs; they may gain a competitive advantage that allows them to stay in New England and continue to contribute to employment and the economic stability of the nation.

Environmental impacts.

- Construction. The installation of wood-fired boilers or gasifiers in small industries and commercial buildings would involve little outside construction to retrofit existing structures. Air and water quality would not be significantly impacted. Local businesses could benefit from hardware sales and services required by installation.

A plant producing 250 to 300 tons per day of pellets (using 500-600 green tons of wood per day: Chamberlain 1977) requires about five acres of land and takes about six months to build (Blackman 1978; BSRD 1978). Air and water quality impacts would be minimal; only the terrestrial ecosystem of the plant site would be severely affected during construction. Since most plant components are prefabricated, employment increases during construction would be small and of short duration.

- Operation. Maine state air quality regulations control emissions and require air pollution licenses from boilers with rated outputs of 10 million Btu per hour or greater. Particulate standards apply to equipment fired at 3 million Btu per hour, and all boilers are subject to visible emission standards (Berger & Lohnes 1979). The operation in one geographic region of numerous boilers with inputs less than 3 million Btu each could result in local air quality problems. Regulation of larger boilers should adequately limit total emissions, however.

Ash from wood boilers will probably be disposed of in land-

fills but should not result in other significant impacts if the landfills are properly designed (see Section 3.2.6). The ash could also be used as a soil conditioner.

- Fuel procurement impacts. Fuel procurement impacts for commercial and industrial applications would be similar to those for the proposed wood-fired power plant. Whole-tree chipping would probably be employed.

- Transportation impacts. Transportation impacts would be similar to those of the proposed plant; chips would be delivered by vans. Dispersion of deliveries would minimize traffic problems, although the establishment of a central concentration yard or pelletizing plant would have local impacts on traffic similar to those of the wood-fired power plant.

- Relationship to national, state or local plans and policies. This alternative would further the goals of the National Energy Act (1978), the Maine Comprehensive Energy Plan (1976), and the Threshold to Maine Resource Conservation and Development Project (1977). It would complement the Small Business Administration's Small Business Energy Loan Program, and other federal loan programs related to energy conservation and economic development.

- Summary of long-term impacts. Harvesting presents the impacts of primary concern for this alternative. These impacts are discussed in Section 3.3.4. The use of wood as a fuel will create jobs in the region and contribute to the improvement of the balance of payments. Fossil fuels would be released for other uses.

5.5.2 Synthetic Fuels

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support the use of wood for the production of synthetic fuels.

Description

The Department of Energy could encourage the use of wood for the production of synthetic fuels such as methanol, ethanol, oils, or charcoal. These fuels offer advantages over green chips in ease of handling, Btu content, and fuel uniformity. However, low processing efficiency reduces the value of these products except in special circumstances.

Methanol is produced synthetically from carbon monoxide and hydrogen. It can be synthesized from any carbonaceous material, such as coal, wood waste, agricultural residues, or garbage (Hokanson & Rowell 1977). Methanol production from coal is under intense development; synthesis from municipal solid waste has been successful. However, methanol is presently produced most economically and efficiently using natural gas. Conversion from solid materials requires additional processing and is more energy-intensive than the process using natural gas (Hokanson & Rowell 1977). Plant efficiency with wood feedstock is only 38 percent; for gas, it is 61 percent (see Table 5.5.2-A) (Saeman 1977a).

Coal is a more efficient fuelstock than wood (plant efficiency is 59 percent) because of its higher carbon and lower oxygen content (USFS 1976). In addition, coal is a centralized resource while wood is dispersed; large transportation costs must be incurred to collect wood in the quantities required for centralized production.

The efficiency of methanol production from wood depends on improvements in the gasification process (Inman 1977). At the present, methanol production from wood does not appear to be economically feasible (Hokanson & Rowell 1977).

The biology of the fermentation process used to produce ethanol from wood is well known, but wood feedstock requires energy-intensive and expensive pretreatment to break down the cellulose crystals and lignin association (Brenemann 1978). The complexity of the process is reflected in the high investment requirements. Production from ethylene or grain is less expensive (see Table 5.5.2-B).

A multiproduct firm might produce ethanol more profitably, but marketing the fixed ratios of ethanol, furfural, and phenols

TABLE 5.5.2-A: COMPARISON OF GAS, COAL, AND WOOD AS SOURCES OF METHANOL[1]

Raw Material	Product Output *(10^6 gal/yr)*	Plant Efficiency[2] *(percent)*	Plant Investment *(million dollars)*	Selling Price *(dollars/gallon)*
Gas	50	61.3	23.1	.46
Coal	50	59.0	74.4	.98
Wood	50	38.0	64.0	.98
Gas	200	61.3	61.0	.35
Coal	200	59.0	178.0	.78
Wood	200	38.0	169.0	.83

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1. *Assumptions: 30% profit on investment, 15% after federal taxes; natural gas at 1,000 Btu/cubic foot, $1.75/thousand cubic feet; coal at 19% ash, 8,660 Btu/pound, $38/ton; wood waste (Douglas fir) at 25% bark, 9,000 Btu/pound, $34/ton.*
2. *Plant efficiency = heat value of methanol as percent of total energy input into plant.*

Source: Saeman 1977a.

over the lifetime of the plant make it a high risk investment (Saeman 1977b). One profitable multiproduct plant would increase the nation's production of furfural by two-thirds (Saeman 1977a). Experience with the hydrolysis of hardwoods is limited to pilot plant studies (Saeman 1977b). Since the low-quality wood available in Maine is primarily hardwood and bark, a multiproduct plant is not yet commercially viable.

Production of furfural in a single-product plant is economically infeasible. Phenol production data is speculative (Saeman 1977a).

An experimental hydrogenation plant producing two barrels of oil per ton of dry wood chips is operating in Albany, Oregon, with Department of Energy support. Production of liquid fuel from coal is more economic, however (Zerbe 1978).

Pyrolysis produces gases, oil, and charcoal. The oils tend to be corrosive and viscous and to have a low heat of combustion (Brenemann 1978). The process can be modified to alter the mix of products. If the gaseous products of pyrolysis can be burned before production heat is lost, process efficiencies of 85 percent can be attained (Zerbe 1978). A new pyrolysis process producing a fuel composed of a fifty/fifty char-oil mix and a combustible gas is being tested at the Georgia Institute of Technology (Zerbe 1978).

In addition to problems with process efficiency and economics, synthetic fuels suffer from transportation and delivery inefficiencies. When wood is burned to create space heat or to fuel a power plant, the fuel is transported to a central location and used at the point of delivery. Wood transported to a synthetic fuel plant must be processed into a different form and then delivered to its point of ultimate use. This two-step transportation process reduces the overall efficiency of using wood to produce synthetic fuels and favors the use of coal, which is mined in large quantities at one location.

While the technology for synthetic fuels is progressing, none of the processes appear commercial at the present time:

TABLE 5.5.2-B: SELLING PRICE OF ETHANOL FROM WOOD, ETHYLENE, AND GRAIN[1]

Raw Material	Product Output (10^6 gal/yr)	Wood Input (tons/day)	Plant Investment (million dollars)	Selling Price (dollars/gallon)
Ethylene	25	--	20	0.91
Grain	25	--	25	1.43
Wood	25	1,480	70	1.90
Ethylene	100	--	53	0.76
Grain	100	--	66	1.23
Wood	100	6,000	185	1.42

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1. Assumptions: 30% profit on investment, 15% after federal taxes; ethylene at $.11/pound; grain at $3/bushel; wood waste at $34/ton.

Source: Saeman 1977a.

> "The characteristics of wood reduce its usefulness as a source of clean liquid and gaseous fuels or as a versatile starting material for high-volume organic chemicals. It is a safe generalization to say that for the next decade at least, the most efficient way to use wood as a source of gas or liquid fuels will be to divert such fossil fuels from furnaces and burn wood instead. With rare exceptions, organic chemicals can be made more efficiently from petroleum saved by burning wood than directly from wood itself." (Saeman 1977a).

Since the proposed project is intended to demonstrate the immediate commercial feasibility of producing energy from wood, none of the synthetic processes is a viable alternative to the wood-fired power plant. The Department of Energy, however, is supporting research to design and test intermediate and long-term prospects for the production of synthetic fuels from wood. Therefore, this alternative is not considered further here.

5.5.3 Nonenergy Uses of Wood

Consumptive Uses

Policy statement. As an alternative to the proposed action, the federal government could encourage the use of wood to produce materials like reconstituted wood products, which could contribute to an overall energy conservation effort if they were substituted in construction for materials such as aluminum or steel.

Description. In stimulating the use of 680,000 tons of wood as an energy source for cogeneration, the U.S. Department of Energy would promote the use of rough and rotten wood, the by-products of timber stand improvement, and manufacturing residues. This poor-quality material was unmarketable until the high costs of oil made wood more valuable as a fuel resource. Recent technological developments, however, are also improving the ability of the forest industry to utilize poor-quality wood for reconstituted wood products and pulp manufacture.

The raw material requirements for reconstituted wood products are not critical, the production process is automated, and yields are on the order of 75 to 80 percent. The product -- particleboard -- has numerous advantages over traditional wood materials:

low variability in properties, dimensional stability, good weathering characteristics, good strength- and stiffness-to-weight ratios, and good fastening properties (Saeman 1973).

Reconstituted wood products can be used as a substitute for more energy-intensive materials such as steel, aluminum, and brick. According to a study by the Committee on Renewable Resources for Industrial Materials (CORRIM), steel floor joists require fifty times as much energy as wood joists; aluminum framing is twenty times as energy-intensive as wood framing; brick siding requires twenty-five times the energy of wood-based siding. In addition, wood's insulating properties are superior, providing savings in energy for space heating. Not only are energy requirements for wood products low, but most wood processing firms are at least partially energy self-sufficient, using their own wastes for energy (Jahn & Preston 1976). Manufacture of reconstituted boards requires 7.5 to 20 million Btu per ton (Koch 1976). As an alternative to the proposed project, the federal government could support the use of the 680,000 tons of low-quality wood as a material by providing financial or technical assistance to plants producing particleboard, strandwood, or other similar composite boards.

Economics. In the long run, the fuel value of wood sets its minimum value for other uses (Saeman 1977b). For example, pulp has a product value about three times that of wood waste converted to methanol (Hokanson & Rowell 1977). Value is added in processing wood as a material with resulting indirect stimulation of the local economy. These plants can be relatively energy self-sufficient by using process wastes and other wood for process and space heat. Wood used in the manufacture of materials can be recycled; once converted to a fuel and burned, it is lost for other uses.

Marketing and purchasing strategies favor larger, capital-intensive plants; the economies of scale are dictated by off-the-shelf equipment. In 1976, a plant consuming 200,000 to 280,000 green tons per year and producing panel-type composites cost about $10 million. A smaller installation was feasible at that time

with a captive or controlled market (Gatslick 1976). Yield of composite board is about 416 square feet per ton of wood (UNH 1966). Thus, the use of 240,000 tons per year would produce 100 million square feet per year.

Environmental impacts. The nature of the construction impacts of a reconstituted board plant would be similar to those for the proposed project, although the scales would differ. In addition to buildings, equipment, and wood storage facilities for materials manufacture, a wood energy system would be required to provide space and process heat for the facility.

Particleboard manufacture is a dry process; no water would be discharged. Emissions from the gluing process apparently are negligible, although fumes inside plants using urea-formaldehyde as an adhesive can cause concern (Marra 1979). Operation requires process heat that can be produced by burning wood. Impacts for process heat would be similar to those for the proposed project, although smaller in scale (see Section 5.5.1). Wood handling facilities would also be similar to those of the proposed project, although there would be one system to handle material feed and another to handle fuel chips. Jobs would be created by operation of the plant, and benefits from employment would accrue to the local economy. One proposed plant, using 160,000 green tons of wood and producing 100 million square feet of particleboard per year (three-eighths-inch basis) planned to employ 101 people and projected the creation of 350 secondary jobs (Valley News 1978).

Impacts of wood procurement would be similar to those for the proposed project. Transportation impacts would also resemble those for the proposed wood-fired power plant. However, transportation of products from the plant to wholesale distributors would add to the amount of truck traffic and the overall energy budget.

This alternative would enhance local and state programs to create jobs and industry using local resources. The goals of the National Energy Plan would indirectly be served, since wood materials are more energy-efficient than substitutes.

Utilizing 680,000 tons of wood for the manufacture of composite products would create jobs and benefit the economy. However, the long-term management and productivity of the forest must be preserved with the same sound forest practices that are required for the proposed project and for alternative uses of the wood to generate energy.

Nonconsumptive Uses

Policy statement. As an alternative to the proposed action, the United States government could support nonconsumptive uses of forest lands.

Description. Federal agencies could encourage uses of Maine woodlands that do not require the harvest of wood. Funding could instead be provided for the improvement of woodland wildlife habitat, including fisheries, in cooperation with the Maine Department of Inland Fisheries and Wildlife or private conservation organizations.

Wilderness or natural area protection or acquisition could be promoted through appropriate state agencies and private landholding organizations such as the Audubon Society or the Nature Conservancy. Federal funds encouraging acquisition and transfer of property or conservation easements would support this end.

Undisturbed ecosystems serve as a benchmark against which changes in the unprotected landscape can be measured. Scientific study of these natural areas provides important information on plant and animal lifecycles, succession, and other natural phenomena vital to our knowledge of the natural systems that man manages, uses, and, sometimes, abuses. Funding for land acquisition should include provisions for maintenance of the property.

Protected wilderness areas, if accessible, also provide an outdoor laboratory for educational purposes. Undisturbed processes of growth, decay, and ecosystem development can be observed. Natural areas provide the opportunity for "wilderness experiences" for recreationists seeking solitude, natural surroundings, and wildlife viewing. Hunting and fishing may or may not be allowed.

Environmental impacts. The impacts of this alternative will result from the removal of the wood resource from direct economic use. Locally, wilderness designation can affect the livelihoods of woodsworkers and employees of the wood products industries, and may produce adverse public reaction. On the other hand, increased environmental awareness and improved scientific knowledge would benefit society as a whole. In addition, natural area designation helps to protect threatened and endangered species and to preserve the diversity of the native gene pool.

Wilderness recreation is enhanced by preserving natural areas, but this may be at the expense of more intensive recreational uses. People lacking the stamina or skills to enjoy the back country are excluded from use of wilderness areas by the lack of access roads and developed facilities.

Relationship to national, state, or local plans and policies. The Maine Critical Areas Program has identified noteworthy natural features in the state for inclusion in Official Register of Critical Areas. The program was created by the state legislature in 1974 to encourage and coordinate the conservation of such areas. The areas identified by this program would have priority in a federal acquisition project.

Both the Time and Tide and the Threshold to Maine Resource Conservation and Development Projects identify fish and wildlife habitat improvement and recreational development as project objectives. The Time and Tide Program of Action also encourages preservation of unique natural areas. Coordination with Resource Conservation and Development Project activities could enhance nonconsumptive uses of forested land through local support.

The Maine Statewide Outdoor Recreation Plan calls for the acquisition of land for recreation, including wilderness and wildlife areas. In particular, for southwestern Maine, acquisition of land to fill in the boundaries of the Evans Notch District of the White Mountain National Forest and the Rachel Carson National Wildlife Refuge is recommended. The Plan also recommends that the Maine Bureau of Parks and Recreation prepare a State Park Plan to address specific needs of the State Park System. A State Park

Plan would provide guidelines for land acquisition and preservation.

On the federal level, the Roadless Area Review and Evaluation (RARE II) of the U.S. Forest Service has recently reviewed areas in the National Forest System for wilderness designation. While no lands in Maine have been designated under this program, RARE II has brought wilderness designation to the public attention in New England. Removal of timberland in the White Mountains of New Hampshire from harvestable status because of its designation as a roadless area could increase pressure on the forest resource of Maine and prompt conservationists to push for more wilderness areas in the state.

5.6 ALTERNATIVE PLANT DESIGNS

5.6.1 Generation of Steam Only

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a wood-fired steam generating facility producing 510,000 pounds of steam per hour at the Westbrook mill.

Description

A steam boiler operating at 510,000 pounds per hour would be fueled with a mixture of harvested wood and mill residues collected throughout southern Maine and southeastern New Hampshire. The quantity of fuel required would be slightly lower than that consumed by the proposed cogenerating facility (Manar 1979a). A chip storage pile, wood handling facilities, and an ash disposal system would be required at the mill site. The electric generators, switchyard, and cooling towers required by the proposed cogenerating facility would not be needed for this alternative.

In all other respects, this alternative would be identical to the proposed cogenerating facility described in Chapter 1.

Economics

The costs associated with the wood-fired steam boiler are similar to those described for the proposed facility. The elimination of requirements for the equipment related to electrical generation will reduce the overall capital requirement by approximately $10 million (Manar 1979b).

Table 5.6.1-A presents these costs along with the annual operating, maintenance, and fuel costs.

The unit production costs of this alternative are subject to many variables. Many factors, will influence the costs of capital, operation, maintenance, and fuel. However, the estimates in Table 5.6.1-A indicate that this alternative is at least marginally commercial and that consideration of its environmental impacts is justified.

TABLE 5.6.1-A: ESTIMATED CAPITAL, OPERATING AND MAINTENANCE, AND FUEL COSTS OF A 510,000 POUND PER HOUR WOOD-FIRED BOILER[1]

	1979 Dollars *(millions)*
Installed Capital Cost[2]	53.0
Annual Operating and Maintenance Cost[3]	1.3
Annual Fuel Cost[4]	8.5

1. *Estimates will vary significantly from site to site and should be considered only approximations.*
2. *Calculated from Manar 1979b.*
3. *Assumed to be 2.5% of installed capital cost.*
4. *Based on a fuel price of $12.50/ton (Allison 1979).*

Environmental Impacts

The steam-only facility would produce a small amount of thermal effluent (Manar 1979a). Heat recycling and energy conservation programs at the Westbrook mill could minimize the impacts on the Presumpscot River of this discharge.

All other environmental impacts are virtually identical to those associated with the proposed action described in Chapter 3.

Relationship to national, state, or local plans and policies. This alternative is generally compatible with federal and state initiatives to utilize wood for energy. The decision to construct a steam-only facility in place of a cogeneration system does not reflect federal and state policy as expressed in the Public Utility Regulatory Policies Act of 1978 and the Maine Comprehensive Energy Plan (MOER 1976).

Summary of long-term effects. In the long term, this alternative would have significant effects on the forests and related ecosystems of southern Maine. The potential negative and positive aspects of these effects are fully described in Chapter 3. This alternative would contribute to a reduced dependence on limited supplies of imported fossil fuels.

5.6.2 Generation of Electricity Only

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support the construction of a 50-megawatt wood-fired electric generating station.

Description

A 50-megawatt wood-fired electric generating station would require between 708,000 and 843,000 tons per year of wood fuel (Sherwood & Meadows 1978). The fuel would be obtained from harvesting operations and wood residue producers. The facility could be located at any of numerous sites in Maine where the transportation system and water source were adequate. The characteristics of this facility would be similar to those of the proposed 50-megawatt cogenerating facility described in Chapter 1, except that the steam would be used only to generate electricity.

Economics

The costs associated with a 50-megawatt electric generating plant are presented in Table 5.6.2-A. With the exception of the expense for a larger turbine generator, these costs are identical to those associated with the proposed action.

The unit production costs of this alternative are subject to many variables. The existing tax climate, location of the plant, and the financial status of the owner firm will influence the costs of capital, operation, maintenance, and fuel. However, the estimates in Table 5.6.2-A indicate that this alternative is at least marginally commercial and that consideration of its environmental impacts is justified.

Environmental Impacts

While the environmental impacts of a 50-megawatt wood-fired electric cogenerating plant are similar to those described in Chapter 3, the location of the plant could alter the impacts and might affect public recreational access to Maine's inland or coastal water resources. Emissions and effluents should be identical to those of the proposed action, except that somewhat more waste heat may be discharged and a less efficient use of energy attained.

Relationship to national, state, or local plans and policies. While this alternative is compatible with federal and state initiatives to utilize wood as an energy source, the choice of an electric-only facility over a cogenerating facility would not reflect the policies established by the Public Utilities Regulatory Policy Act of 1978 and the Maine Comprehensive Energy Plan of 1976.

Summary of long-term effects. The fuel procurement program needed to supply this facility would have significant implications for the management of forest and related ecosystems in southern Maine. The potentially positive and negative impacts of wood fuel collection are fully discussed in Chapter 3. This alternative would assist a regional transition from dependence on nonrenewable sources of energy to a sustainable energy system.

TABLE 5.6.2-A: ESTIMATED CAPITAL, OPERATING AND MAINTENANCE, AND FUEL COSTS OF A 50-MW WOOD-FIRED ELECTRIC GENERATING FACILITY[1]

	1979 Dollars *(millions)*
Installed Capital Cost[2]	57.0
Annual Operating and Maintenance Cost[3]	1.4
Annual Fuel Cost[4]	8.8-10.5

1. *Estimates will vary substantially from site to site and should be considered only approximations.*
2. *Calculated from Manar 1979c.*
3. *Assumed to be 2.5% of installed capital cost: Manar 1979a.*
4. *Based on a fuel price of $12.50/ton (Allison 1979) and fuel consumption of 705,000 to 843,000 tons of wood per year (Sherwood & Meadows 1978).*

5.6.3 Alternative Engineering Systems

The information presented below was supplied by the Rust Engineering company (Finn 1979b) and describes the alternative system designs that were evaluated during the design of the proposed wood-fired power plant.

Cooling System Design

The proposed wood-fired power plant will employ a one- or two-cell, induced draft, cross flow cooling tower to reject heat from the proposed wood-fired boiler. Two alternatives to this system were evaluated during the design of the cooling system: straight-through cooling with a direct discharge to the Presumpscot River and a combination straight-through/cooling tower system. Preliminary calculations were run to assess the impact of these systems on the thermal quality of the Presumpscot River. These calculations showed that a once-through cooling system or a combined system would result in violations of the allowable temperatures in the Presumpscot during certain operation times including periods of high thermal discharge in summer coupled with low river flows. Discussions with the Maine Department of Environmental Protection indicated that the Board of Environmental Protection would not allow once-through or partial systems in this case.

Ash Handling and Disposal

Both dry and wet ash-handling systems were evaluated for use in the proposed plant. A system featuring dry handling for the precipitator and siftings hopper, and wet handling for the boiler ash has been chosen. The dry handling systems were chosen because their compact size allows them to fit within the space available near the precipitator and the siftings hopper. The wet handling system for boiler ash disposal was chosen to reduce fire hazard in the overall ash-handling system. Initially, a pneumatic ash-handling system was considered as the method to remove and convey the fly ash to silos. This system was rejected because of explosion and fire hazard resulting from the hot char that is handled along with the fly ash through the pneumatically-operated system.

Dewatering bins were initially considered as an intermediate step in the ash-handling system between ash collection and deposition into the ash ponds. The short retention time in the bin, however, would have resulted in a contaminated water overflow which would have been prohibitively costly to treat before discharge into the Presumpscot. Additionally, an unacceptably large flow would have been generated with the use of dewatering bins. For these reasons, this system was discarded and the ash will flow directly into ash ponds. The water used to convey the ash will be recirculated in an essentially closed loop.

The alkaline properties, potash content, and mineral content of the wood ash make it a suitable soil conditioner or, with additives, a fertilizer. If a market for the wood ash can be established, an ash-handling system can be provided wherein the ash would be packaged and delivered to potential retailers or wholesalers. This possibility is under continuing investigation.

Water Treatment System

Three water treatment systems for the preparation of high-quality feedwater for the wood-fired steam generator were considered. These systems included:

A. Anthracite-sand filtration and activated carbon filtration followed by two-bed and mixed-bed ion exchangers;

B. Activated carbon filtration followed by two-bed and mixed-bed ion exchangers;

C. Activated carbon filtration followed by mixed-bed ion exchangers.

System C was selected because it will generate less wastewater and the wastewater will have a pH compatible with the U.S. Environmental Protection Agency's regulations. Additionally, System C requires less space than the other systems and has lower capital and operating costs.

Pressure Level of the Boiler

Current technology in the burning of wood-fuel limits the pressure level of the boiler to an operating level of 1,500 pounds per square inch guage (psig). A range of operating pressures was

considered for the proposed boiler and levels lower than 1,500 psig could be employed at the proposed plant site. However, the 1500 psig level provides the highest cycle efficiency and has been chosen for that reason.

Steam Cycles

Alternative heat balances and steam cycles were evaluated for cogeneration at the S.D. Warren Company mill. Because of the high expense associated with reworking existing steam facilities used in the pulp and papermaking process, turbine extractions were selected to be compatible with the existing S.D. Warren steam system.

Fuelwood Drying

Predrying fuelwood before injecting it into the boiler reduces the moisture content of the wood and thus improves the efficiency of combustion. Three systems were considered for predrying the wood:

A. Separately fired bark dryers which dry the fuelwood through combustion of wood or some other fuel prior to the fuelwood's entry into the boiler feed system;

B. Hot hogs which dry the fuelwood while processing the wood chips to make them more uniform in size;

C. Flue-gas dryers which use heat in the stack emissions stream to dry chips prior to injecting them into the boiler.

Flue-gas bark dryers were selected because they have been operated successfully and economically in the past.

Generator Cooling System

Two generator cooling systems were considered for the proposed wood-fired power plant: air-cooled systems and hydrogen-cooled systems. Although hydrogen-cooled systems operate more efficiently than air-cooled systems, their higher initial capital costs could not be justified and thus air-cooled generators were chosen.

5.7 ALTERNATIVE FUELWOOD SUPPLY SYSTEMS

5.7.1 Alternative Harvesting Strategies

Policy Statement

The proposed wood-fired power plant will receive fuelwood in the form of chips that have been processed at the harvest site by a whole-tree chipper and transported to the facility in chip vans. As an alternative, standard logging procedures could be employed to produce logs to be chipped at the power plant.

Description

Fuelwood for the proposed action will be harvested from the region's forests with mechanized operations that produce one- to two-inch chips from whole trees. These chips will be procured from private logging contractors who in turn will acquire cutting rights (stumpage) from individual landowners. It is expected that a wide variety of harvest systems (clearcutting, shelterwood, selective) and thinning strategies will be employed to supply these chips. The impacts of these various methods are discussed in Section 3.3.

Two major alternatives exist for the procurement of fuelwood. Wood could be grown and harvested on silvicultural energy plantations. This intensive system is not economically feasible in view of the less expensive, abundantly available, low-quality wood in the region's forests. Also, because of the long start-up time, wood would not be immediately available from this source. The Department of Energy is investigating the intermediate and long-term feasibility of this alternative in other research programs; consequently it will not be considered further here.

The most feasible alternative to whole-tree chipping would be standard logging operations to cut logs which could then be chipped or hogged after delivery to the power plant. With this type of operation, better quality trees would be harvested, since the inefficiencies of transporting crooked logs constrain their use. If only the boles were taken, at least 50 percent of the combustible fiber would be left in the forest as tops and branches. Therefore, it is likely that almost twice as much land would be

necessary to produce a given amount of wood for energy with the bole-only alternative.

Economics

Employment of bole-only harvesting may result in higher prices for fuelwood than those that would prevail if whole-tree chipping were employed. The major expense of acquiring and using wood resources results from the costs associated with handling the bulky, heavy, irregularly-sized trees. Whole-tree chipping at forest landings reduces the fiber from the whole tree into a much more uniform and readily transportable material.

Stumpage fees for the bole-only system may be as high or higher than those for whole-tree removal. As stated earlier, shipment of logs necessitates leaving the tops and branches in the forest. Thus the fee paid to the landowner per unit of material recovered may be substantially higher with the bole-only alternative. Also, processing logs at the power plant site is more expensive and time-consuming than processing chips.

One advantage of bole-only harvesting is that less capital investment is required of logging contractors in the fuelwood business. The necessity of having a chipper operating at the landing can substantially increase harvesting capital costs (see Appendix E) and may prevent some contractors from entering the market.

Environmental Impacts

The environmental impacts of this alternative would be similar to those described for the proposed action in Section 3.3. The major differences result from the disposal of tops, branches, and deformed trees left in the forest as slash. The exact nature of the resulting impacts would depend on how the slash was managed. If typical practices for the Northeast are followed, the slash would be left where the trees were felled and would be allowed to decompose slowly on the site. In this case, the slash would provide some shading for the forest floor following the removal of the tree canopy. Shade slows the rates of soil litter and organic matter decomposition (see Section 3.3) and provides variations in soil microclimate that may favor more diverse regeneration of the stand.

Initial regeneration failure has been observed on south-facing slopes in Vermont following slash removal, whereas similar slopes have regenerated successfully following a bole-only harvest. However, slash may also impede reproduction of the stand as a result of heavy shade, mechanical suppression, or provision of a microclimate suitable for competitive herbaceous plants and shrubs (Smith 1962).

As the slash decomposes over a period of ten to twelve years, it provides a substantial nutrient input to the new or remaining stand and typically improves the physical properties of forest soils (Smith 1962). This effect is enhanced because decomposing slash serves as a site for nitrogen fixation by decomposing bacteria (Roskoski 1975). Slash remaining on the forest floor reduces the rate of soil organic matter decomposition, and thus effectively reduces the leaching of nutrients into groundwater and streams. Slash also acts as a buffer to reduce the rate of sediment transport in surface water flow, although the significance of this effect is questionable (Smith 1962). By the time slash begins to decompose, the new stand is generally sufficiently established to retain a high percentage of the available nutrients. Slash also provides habitat for wildlife species such as rabbits and ground-nesting birds.

The vast majority of insects and fungi that feed on logging residues benefit the forest by decomposing slash and making its nutrient content available. Few of these species attack living trees (Smith 1962). However, some bark beetles and heart-rot fungi do thrive in cull logs and large branches and may establish populations that threaten the new or residual stand of trees.

Slash left in the forest can provide a fuel source which, if ignited, can speed the spread of forest fires and hinder the movement of fire-fighting efforts. Small branches and twigs can provide tinder ideal for starting wildfires but this material generally decomposes quickly following harvest. Slash is not perceived as a major fire menace in the Northeast, where precipitation is rather evenly dispersed throughout the year.

Slash represents a major aesthetic nuisance to many people, who may perceive it as a hazard, a sign of poor forest practices,

or simply a mess. This problem can be mitigated by removing slash from highly visible areas.

The use of bole-only harvesting in the Northeast typically means that substantial quantities of tops, limbs, and branches are left in the forest. The employment of this harvest system would fail to demonstrate the commercial viability of whole-tree harvesting for the production of fuelwood, which would reduce the total amount of fuelwood available immediately. These events could slow the development of the use of wood to produce energy in New England. The disposal of slash in the forest represents both beneficial and harmful impacts as seen above. Continuation of this practice, as an alternative to the proposed system which would remove slash, however, could reduce the danger of long-term nutrient depletion of the forest (see Section 3.3.3).

5.7.2 Alternative Residue Systems: Agricultural Residues

Policy Statement

As an alternative to the proposed action, the U.S. Department of Energy could support a program to collect and utilize agricultural wastes for the production of energy in southern Maine.

Description

The characteristics and requirements of a facility designed to burn crop residues and animal manure, as either supplementary or primary fuels, are generally similar to those of the proposed wood-fired facility. An extensive collection network would be required to collect these residues, which are dispersed at a relatively low density over a wide area in southern Maine. Table 5.7.2-A outlines the availability of these fuels in the counties that intersect the fifty-mile radius harvest region of the proposed plant.

While the crop residues could be chopped and dried to provide useful fuel, the animal manure would have to be converted to a gas before it is burned (SRI 1978). Table 5.7.2-B describes the energy content of agricultural residue fuels after processing.

TABLE 5.7.2-A: ANNUAL AVAILABILITY OF CROP RESIDUES AND ANIMAL MANURE

County	Crop Residues[1] *(dry tons)*	Animal Manure[2] *(dry tons)*
Maine		
Androscoggin	1,006	27
Cumberland	2,028	15
York	1,491	17
Kennebec	594	36
Lincoln	424	3
Oxford	2,675	13
Sagadahoc	0	2
New Hampshire		
Belknap	194	282
Carroll	166	144
Strafford	177	417
Total	8,755	956

1. *Includes all crop residues wasted and left in the field.*
2. *Includes only manure wasted, since residues used as feed, fuel, or fertilizer are not available for use at the biomass facility.*

Source: SRI 1976.

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From this information, it is calculated that the total energy contribution from agricultural wastes could not exceed 2.4 percent of the gross energy input of the proposed power plant. The extremely limited availability of these fuels precludes further consideration of this alternative.

5.7.3 Alternative Transportation Systems

Policy Statement

As currently planned, most of the fuelwood will be transported as chips to the proposed wood-fired power plant, in large truck vans and railcars (JPR 1979). No transportation controls have been designed specifically for this project. There are three major types of alternatives to this proposed transportation system -- modal alternatives, implementation of transportation controls, and the implementation of harvesting controls. These alternatives are summarized in Table 5.7.3-A.

Description

Modal alternatives. There are two major modal alternatives to the present plan for transporting the wood chips to the proposed wood-fired power plant. Chips could be delivered to the plant by rail only or trailer-on-flatcar systems. Trailer-on-flatcar systems would require construction of loading and unloading ramps for moving truck vans on and off the flatcars.

A rail-only transport system would actually have to rely on trucks to move wood from the harvest site to a central railcar loading station. Trucks could haul roundwood to be chipped at the station and blown into railcars. In this case, as much as 50 percent of the fuelwood value of harvested trees would be left in tops and branches in the forest (Hewett 1978). Alternatively, chip vans could transport chips from whole-tree harvesting operations to be reloaded into railcars at the rail landing. In this case, expensive equipment suitable for unloading chip vans and reloading railcars would have to be provided at each landing (Adler, Blakey & Meyer 1978).

TABLE 5.7.3-A: MAJOR ALTERNATIVES TO PROPOSED TRANSPORTATION SYSTEM

Modal Alternatives	Description
Rail Only	Use rail for long-distance haul of fuel
Rail/Truck	Use both truck and rail for long-distance haul of fuel
Transporation Controls	
Wood Unloading Schedule	Accept wood fuel at plant at specified times of the day and on specified days only
Routing	Use only pre-specified routes for truck travel
Vehicle Loads	Accept fuel only from trucks acceptably loaded
Vehicle Condition	Accept fuel only from vehicles meeting maintenance criteria
Harvesting Controls	
Geographic Distribution	Harvesting (or wood removal) in dispersed areas
Timing	Chip vans loaded at specified times

Transportation controls. A number of controls could be implemented to ease the impacts of trucking wood chips to the wood-fired power plant. Any facility accepting wood deliveries can establish unloading hours, which helps to minimize traffic impacts. If the truck fleet were owned by the power plant or managed under restrictive contract, routing controls could be instituted. These would ensure that the plant's truck traffic avoided sensitive neighborhoods, congested areas, or fragile streets and roads. A wood-fired power plant could also institute a strict policy of refusing to unload overweight trucks arriving at the woodyard, and could establish an inspection and permit program that ensured that chip vans delivering wood were maintained according to certain standards.

Harvesting controls. Harvesting policies also can affect the impacts of trucking. If harvesting were geographically dispersed, truck concentrations on any one route would be relatively small. Similarly, loading of wood chip vans could be timed so that the trucks would not travel during local peak traffic hours.

Economics

Using both rail and trucks for transporting fuel to the plant would add considerable capital expense to the facility. Truck-railcar transfer equipment for a single site, including a blower system, a dumper and hopper, and a conveyor, would cost approximately $500,000 (Adler, Blakey & Meyer 1978). Railcar unloading equipment would cost from $200,000 to $600,000, making the total cost of the rail-only system approximately $1 million (Adler, Blakey & Meyer 1978).

Other alternatives are not as capital intensive, but some will add to the operating costs of the plant. If truck routing is controlled, trips will probably be longer. Transportation costs are directly related to trip length. Total yearly transportation operating costs will be approximately $2 million (assuming the trucks are carrying 680,000 tons per year an average of 50 miles per trip at $.06 per ton-mile: assumptions from Finn 1979a and Adler, Blakey, & Meyer 1978). Therefore, a rerouting scheme that increased trip lengths by 10 percent would increase costs by

$200,000 per year. Other controls on transportation activities, such as establishing limited unloading schedules and refusing overloaded or poorly maintained trucks, are likely to have some effect on rate negotiations with haulers. A resulting increase of, for example, $.005 per ton-mile would add approximately $170,000 to the plant's yearly costs. The actual increase in operating costs will, of course, depend on the extent of the controls. Minor restrictions on routing, scheduling, and loading would result in cost impacts less severe than those cited above.

Environmental Impacts

A trailer-on-flatcar or rail-only delivery system could reduce or eliminate the volume of chip van traffic arriving at the wood-fired power plant and thus could reduce or eliminate the potential for adverse impacts in the area. These impacts are described in Section 3.5.3. In either case, truck traffic would affect the fuelwood harvest region, since trucks would have to deliver wood from the harvest site to the rail loading site. If the rail loading system concentrated shipments (i.e., if the number of loading sites were less than the number of harvest sites, which would almost certainly be the case), inappropriate location of these loading sites could exacerbate truck-related impacts. For example, if a loading site were located near a highway intersection with inadequate capacity, the truck traffic could add to the congestion at the intersection. Other impacts of increased reliance on rail transportation are negligible (see Section 3.5.2).

Table 5.7.3-B summarizes the effects of the transportation controls alternatives. These alternatives have benefits that at least partially offset their cost, as discussed earlier. Generally, these alternatives could be instituted when or if it became necessary to reduce congestion, noise, air quality deterioration, or highway damage.

Traffic impacts. Of the different impact types, reduction of traffic congestion is the most straightforward. As discussed in Section 3.5.3, traffic congestion arises due to concentration of vehicles in time and in space. Deliveries of wood to the power plant would be distributed in a relatively uniform way over time.

TABLE 5.7.3-B: EFFECTS AND IMPLEMENTATION OF TRANSPORTATION CONTROL ALTERNATIVES

Control	Impact Reduction	Implementation Requirements
Wood Unloading Schedule	Congestion Noise Air quality	Adherence to strict unloading schedule
Routing	Congestion Noise Air quality Bridge maintenance	Full fleet control: i.e., fleet owned by power plant or managed under restrictive contract
Vehicle Loads	Highway maintenance Bridge maintenance Congestion	Weighing at power plant, rejection of overloaded vehicles
Vehicle Condition	Noise Air quality Congestion	Inspection/permit program managed by power plant operator

Deliveries that occurred during Westbrook's peak commuting hours would have the most adverse traffic impact. An extremely effective strategy to control this impact would be to use an unloading schedule that directed wood deliveries away from these peak hours. A measure of this type would significantly reduce the traffic-related impacts of truck deliveries.

Where traffic problems occurred only in certain geographic areas, delivery trucks could be directed to avoid routes passing through those areas. Control over truck routing, however, is difficult to establish, especially over only a particular category of trucks. Special institutional arrangements would be necessary to implement such controls (see Table 5.7.3-B).

The general effect of trucks in the traffic stream is strongly influenced by the condition of the vehicles and in particular by the vehicles' horsepower-to-weight ratio. Poor acceleration at intersections and performance on grades directly affect traffic flow (AASHO 1965). By controlling the condition and design of vehicles, this impact can be minimized (Whiteside et al. 1973).

Noise impacts. The impact of truck-related noise depends both on the magnitude of noise and on the proximity to sensitve land uses. In some cases, timing is also a significant factor; trucks operating early in the morning or late at night when general traffic volumes are low may be more noticeable and bothersome. Adherence to an operating schedule could reduce this noise nuisance (Galloway, Clark & Kerrick 1969). Use of only specified routes could similarly reduce the extent to which power plant trucks impacted sensitive areas (Galloway, Clark & Kerrick 1969). As mentioned earlier, however, control over truck routing is somewhat more difficult to exercise than other controls. While considerable effort has been made to reduce truck noise through mechanical improvements and muffling, further improvements in vehicle design will lead to quieter trucks (Kugler & Piersol 1973) Also, careful maintenance of the vehicles reduces truck noise emissions (Kugler & Piersol 1973).

Air quality impacts. Air quality problems that occurred at particular times of day (e.g., high carbon monoxide concentrations) or in particular geographic areas could be reduced through schedule and routing control. Use of newer, properly maintained vehicles would result in overall reductions in truck emissions.

Highway and bridge maintenance impacts. It was assumed in Section 3.5.3 that trucks would not use bridges posted with limits lower than their gross weights. Strict controls over truck routing could assure conformance with bridge limitations. In addition, a policy to control vehicle gross weights by refusing delivery from violators would reduce possible bridge and highway impacts. Damage to highway surfaces is exponentially related to axle loads (Chastain et al. 1965). Thus, the potential for roadway or bridge damage can be significantly reduced by a strict policy of refusing to unload overweight trucks.

Summary of long-term impacts. A variety of wood transportation alternatives could reduce the impacts of the chip hauling activity. Use of rail transport as a substitute for trucks would require increased investment in loading/unloading equipment but could significantly reduce most impacts of wood hauling. Less expensive transportation and harvesting controls could reduce all categories of impacts due to truck transport. Many of these controls could be quite readily instituted if the impacts of wood chip delivery became unacceptably adverse.

5.8 REFERENCES

AASHO 1965 — American Association of State Highway Officials. A Policy on Geometric Design of Rural Highways, AASHO, Washington, DC (1965).

ACE 1977 — See Section 2.4.

Adler, Blakey & Meyer 1978 — See Section 3.12.

AEC 1974 — Atomic Energy Commission. Final Environmental Impact Statement: Proposed Seabrook Station, units 1 and 2, AEC, U.S. Department of Energy, Washington, DC (1974).

Allen 1978 — Allen, Neal, Executor, Regional Waste Systems, Greater Portland Council of Governments, Portland, ME. Telephone conversation (July 12, 1978).

Allison 1979 — Allison, Gary, Vice-President, Wheelabrator Cleanfuel Corporation, Washington, DC. Speech at New England Wood Energy Advisory Council meeting, Boston, MA (January 22, 1979).

Andus 1976 — Andus, L.J., ed. Herbicides, Physiology, Biochemistry, Ecology, 2nd ed., vol. II (New York: Academic Press, 1976).

API 1978a — American Paper Institute. Report to the Department of Energy on Energy Conservation, Progress of the Pulp, Paper, and Paperboard Industry in 1977, API, New York, NY (1978).

API 1978b — American Paper Institute. "U.S. Pulp, Paper, and Paperboard Estimated Fuel and Energy Use," API, New York, NY (1978).

Atlass 1978 — Atlass, Hadley, Director, Maine State Development Office, Augusta, ME. Letter (January 16, 1978).

Bell 1978 — Bell, Harold, Manager of Purchases and Stores, Bangor and Aroostook Railroad, Hermon, ME. Telephone conversation (December 1, 1978).

Bereny 1977 — Bereny, Justin A. Survey of the Emerging Solar Energy Industry, 1977 Edition, Solar Energy Information Services, San Mateo, CA (1977).

Berger & Lohnes 1979 — Berger, Glenn J., and Lohnes, John. A Guide to Legal and Institutional Factors Affecting The Use of Industrial Wood Boilers in New England, DSD #132, Resource Policy Center, Thayer School of Engineering, Hanover, NH (February 1979).

Black 1976 — Black, Theodore W. "Megawatts from the Wind," Power Engineering (March 1976).

Blackman 1978 — Blackman, T., "Bark Pellets Are High Energy Fuel for Coal/Gas Applications," Forest Industries (February 1978).

Brenemann 1978 — Brenemann, John. Biofuels: A Survey, EPRI ER-746-SR, Electric Power Research Institute, Palo Alto, CA (June 1978).

BLM 1976 — Bureau of Land Management. Final Environmental Impact Statement: Proposed Kaiparowits Project, BLM, U.S. Department of the Interior, Washington, DC (1976).

Broglio 1979 — Broglio, Ronald, Engineering Manager, Rust Engineering Company, Birmingham, AL. Telephone conversation (January 16, 1979).

Bronheim 1978 — Bronheim, H. Future Oil Supply to the Northeastern United States, National Center for Analysis of Energy Systems, Brookhaven National Laboratory, Upton, NY (1978).

BSRD 1978 — Bio-Solar Research and Development Corp. Waste to Woodex: Annual Report, BSRD Corp., Eugene, OR (1978).

Butcher & Buckley 1977 — Butcher, Samuel S., and Buckley, Douglas I. "A Preliminary Study of Particulate Emissions From Small Wood Stoves," Journal of the Air Pollution Control Association27 (4) (1977).

Chamberlain 1979 — Chamberlain, L., Director of Sales, Woodex of Maine, Lincoln, ME. Telephone conversation (January 26, 1979).

Chastain et al. 1965 — Chastain, W.E., et al. "AASHO Road Tests Applied to Design," Highway Research Record #90, Highway Research Board, Washington, DC (1965).

CMP 1977 — Central Maine Power Company. "Petition for Certificate of Public Convenience and Necessity to Erect Permanently Installed Power Generating Facility of More than 1,000 Kilowatts in the State of Maine," Items 9 and 10, docket no. U3238, CMP, Portland, ME (July 6, 1977).

Converse 1974 — Converse, A.O. A Brief Review of Load Management Techniques, Technical Memo No. DVE-1M, Thayer School of Engineering, Dartmouth College, Hanover, NH (1974).

Cover 1978 — Cover, John, Staff Engineer, Rust Engineering Company, Birmingham, AL. Letter (May 24, 1978).

Detwyler 1978 — Detwyler, Richard, Plant Manager, Noyes Tire Co., Westbrook, ME. Telephone conversation (November 30, 1978).

DPR 1978 — Domestic Policy Review. Status Report on Solar Energy, public review copy, DPR Integration Group, Washington, DC (August 1978).

Duff 1978 — Duff, G.F.D. "Tidal Power in the Bay of Fundy," Technology Review (November 1978).

Dvorak et al. 1977 — Dvorak, A.J., et al. The Environmental Effects of Using Coal for Generating Electricity, Argonne National Laboratory, Argonne, IL (1977).

Edelston & Rubin 1976 — Edelston, B.S., and Rubin, E.S. Current and Future Use of Coal in the Northeast, National Center for Analysis of Energy Systems, Brookhaven National Laboratory, Upton, NY (1976).

EIA 1978 — Energy Information Administration. Steam Electric Plant Construction Cost and Annual Production Expenses 1977, 30th supplement, U.S. Department of Energy, Washington, DC (1978).

Eldridge 1975 — Eldridge, Frank R. Wind Machines, MITRE Corporation (Washington: U.S. Government Printing Office, 1975).

EPA 1974 — U.S. Environmental Protection Agency. An Assessment Methodology for the Environmental Impact of Water Resource Projects, EPA-600/5-74-016, EPA, Washington, DC (July 1974).

EPA 1976 — See Section 3.12.

EPA 1978 — U.S. Environmental Protection Agency. Compilation of Air Emission Factors, 3rd ed., AP-42, Supplement 8, EPA, Research Triangle Park, NC (May 1978).

ERDA 1976 — U.S. Energy Research and Development Administration. A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices For the Future. Vol. 2: Program Implementation (Washington: U.S. Government Printing Office, 1976).

Finn 1979a — See Section 3.12

Finn 1979b — Finn, W.D., Project Engineer, Rust Engineering Company, Birmingham, AL. Letter (March 20, 1979).

FPC 1977 — Federal Power Commission. Hydroelectric Power Resources of the United States, FPC, Washington, D.C. (1977).

Galloway, Clark & Kerrick 1969 — See Section 3.12

Gatslick 1976 — Gatslick, Harold B. "What Wood Could Do," Forest Notes No. 126, Society for the Protection of New Hampshire Forests, Concord, NH (Summer 1976).

GCHEE 1977 — Governor's Commission on Hydro-Electric Energy. Report on Hydro-Electric Energy in New Hampshire: Existing and Potential Development, Office of the Governor, Concord, NH (April 1977).

Geary & Jones 1977 — Geary, J., and Jones, W.J. "Solar Energy Conversion," Appendix F of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977).

Gordian 1975 — Gordian Associates, Inc. The Data Base: The Potential for Energy Conservation in Nine Selected Industries, Vol. 8 - Selected Paper Products, Conservation Paper #16, Office of Industrial Programs, Federal Energy Administration, Washington, DC (1975)

GPCOG 1977 — Greater Portland Council of Governments. Areawide Water Quality Management Plan, vol. II, revised, GPCOG, Portland, ME (November 1977).

Graham 1978 — Graham, Foster, General Services Manager, Burlington Electric Company, Burlington, VT. Telephone conversation (July 31, 1978).

Hale 1978 — Hale, Roger, Energy Specialist, Fraser Paper Limited, Madawaska, ME. Meeting (March 16, 1978).

Hall et al. 1976 — Hall, E.H.; Allen, C.M.; Ball, D.A.; Burch, J.E.; Conkle, H.N.; Lawhon, W.T.; Thomas, T.J.; and Smithson, G.R., Jr. Comparison of Fossil and Wood Fuels, Battelle-Columbus Laboratories, Columbus, OH (1976).

Harmon 1978 — Harmon, Donald, Plant Manager, Century Tire Co., Portland, ME. Telephone conversation (December 1, 1978).

Harvey 1978 — Harvey, Warren, Vice President, Public Service Company of New Hampshire, Manchester, NH. Telephone conversation (August 18, 1978).

Hein & Lower 1978 — Hein, G.M., and Lower, B.L. "Energy Requirements for Coated and Uncoated Paper," Journal of the American Pulp and Paper Industry, vol. 61, no. 5 (1978).

Heinrichs 1979 — Heinrichs, Jay. "T on Trial," American Forests, vol. 85, no. 2 (February 1979).

Hewett 1978 — Hewett, Charles E. The Availability of Wood for a 50-Mw Wood-Fired Power Plant in Northern Vermont, DSD #114, Resource Policy Center, Thayer School of Engineering, Hanover, NH (1978).

Hobart 1978 — Hobart, Ray, Plant Supervisor, Yudi Tire Co., Westbrook, ME. Telephone conversation (November 30, 1978).

Hoff 1976 — Hoff, Einar B. "Handling of Forest Products Fuels," in Energy and the Wood Products Industry, Proceedings No. P-76-14, Forest Products Research Society, Madison, WI (1976).

Hokanson & Rowell 1977 — Hokanson, A.E., and Rowell, R.M. Methanol from Wood Waste: A Technical and Economic Study, Forest Service General Technical Report FPL 12, Forest Products Laboratory, Madison, WI (1977).

Houghton 1979 — Houghton, John A., Superintendent of Schools, Madawaska, ME. Telephone conversation (March 19, 1979).

Hughes & Denio 1978 — Hughes, David, Vice President of Engineering, and Denio, Donald, Methods Engineer, Boston and Maine Railroad, Boston, MA. Telephone conversation (December 4, 1978).

Hunt & Babcock 1978 — Hunt, Donald, Manager, Maine Rubber Manufacturing Co., Lewiston, Me., and Babcock, Donald, Manager of Wholesale Division, Snows Tire Co., Lewiston, ME. Telephone conversation (November 30, 1978).

Inman 1977 — Inman, R.E. Silvicultural Biomass Farms: Volume I-Summary, Technical Report No. 7347, MITRE Corporation, Washington, DC (1977).

Jahn & Preston 1976 — Jahn, Edwin C., and Preston, Stephen B. "Timber: More Effective Utilization," Science, vol. 191 (February 1976).

Johnston 1978 — Johnston, Dale, Senior Staff Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (December 4, 1978).

Jones et al. 1977 — Jones, W.J.; Ruane, M.; Carpenter, P.; Raskin, S.; and Tabors, R. "Conservation," Appendix B of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (1977).

JPR 1979 — See Section 3.12.

Kinney 1979 — Kinney, Kenneth, School Superintendent, Bucksport, ME. Telephone conversation (March 20, 1979).

Koch 1976 — Koch, Peter. "Material Balances and Energy Required for Manufacture of Ten Wood Commodities," in Energy and The Wood Products Industry, Proceedings No. P-76-14, Forest Products Research Society, Madison, WI (1976).

Kugler & Piersol — See Section 3.12.

Laaspere 1974 — Laaspere, T. On European Approaches to Managing the Electric Load, Report No. DVE-2, Thayer School of Engineering, Dartmouth College, Hanover, NH (1974).

Labuszewski 1977 — Labuszewski, T. "Wind Energy Conversion," Appendix K of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977).

Lapikas 1979 — Lapikas, Thomas, Fleet Maintenance Engineer, General American Transportation Company, Masury, OH. Telephone conversation (February 15, 1979).

LCC 1978 — Members of the Lincoln Conservation Commission, Lincoln, ME. Meeting (March 14, 1978).

Le, Rubin, & Meier 1978 — Le, T.; Rubin, E.; and Meier, P. Coal Utilization in the Northeast: Vol. 8 - Solid Waste Management Issues and Impacts, National Center for Analysis of Energy Systems, Brookhaven National Laboratory, Upton, NY (1978).

Linnell 1978 — Linnell, William, Technical Director, Lincoln Pulp and Paper Co., Lincoln, ME. Meeting (March 16, 1978).

Lowell 1978 — Lowell, Vaughn, Bucksport Conservation Commission, Bucksport, ME. Meeting (March 15, 1978).

Lowery 1979 — Lowery, James, Financial Analyst, Maine Public Utilities Commission, Augusta, ME Telephone conversation (February 28, 1979).

Magee et al. 1973 — Magee, E.M., et al. Potential Pollutants in Fossil Fuels, Esso Research and Engineering Co., Linden, NJ (1973).

Manar 1978 — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (August 14, 1978).

Manar 1979a — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (February 26, 1979).

Manar 1979b — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Telephone conversation (March 9, 1979).

Manar 1979c — Manar, Otis, Project Engineer, Rust Engineering Company, Birmingham, AL. Meeting (May 17, 1979).

Marra 1979 — Marra, Alan, Professor, Department of Wood Technology, University of Massachusetts, Amherst, MA. Telephone conversation (March 29, 1979).

Mays 1977a — Mays, J. "Wave Energy Conversion," Appendix I of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977).

Mays 1977b — Mays, J. "Ocean and Riverine Current Energy Conversion," Appendix J of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977).

MBAQC 1978 — Maine Department of Environmental Protection, Bureau of Air Quality Control. Air monitoring records for Madawaska, East Millinocket, Lincoln, and Bucksport, MBAQC, Augusta, ME (1978).

McBride et al. 1978 — McBride, J.P.; Moore, R.E.; Witherspoon, J.P.; and Blanco, R.E. "Radiological Impact of Airborne Effluents of Coal and Nuclear Plants," Science, vol. 202, no. 4372 (1978).

MDC undated — See Section 2.4.

MDMA 1979 — Maine Department of Manpower Affairs. Computer file of employment and unemployment estimates, MDMA, Augusta, ME (1979).

Meffert 1978 — Meffert, D.P., Senior Staff Engineer, Rust Engineering Company, Birmingham, AL. Letter (October 26, 1978).

MESA 1975 — U.S. Mining Enforcement and Safety Administration. "Coal Mining Industry Fatalities," MESA, Washington, DC (1975).

MITRE 1975 — MITRE Corporation. An Analysis of Constraints on Increased Coal Production, U.S. Department of the Interior, Washington, DC (1975).

MOER 1976 — See Section 4.3.

NEEC 1978 — New England Energy Congress. Preliminary Report for Public Review, NEEC, Tufts University, Medford, MA (1978).

NEFRC 1976 — New England Federal Regional Council, Energy Resource Development Task Force, Hydroelectric Facilities Workgroup. A Report on New England Hydroelectric Development Potential, NEFRC, Boston, MA (June 1976).

NEPOOL 1971 — New England Power Pool. Contract, amended version, NEPOOL, Westborough, MA (September 1, 1971).

NERBC 1979 — New England River Basin Commission. "Inventory of Low-head Dams," unpublished computer printout on file at NERBC, Boston, MA (1979).

Newkirk 1976 — Newkirk, H.W., ed. Environmental Effects of Energy Production and Utilization in the U.S., vol. I-III, Lawrence Livermore Laboratories, University of California, Livermore, CA (1976).

NOAA 1978 — National Oceanic and Atmospheric Administration. "Harnessing Tidal Energy," Current Issue Outline 78-2, U.S. Department of Commerce, Washington, DC (1978).

Noyes 1974 — New England Waste Treatment Company. Feasibility Study for Noyes Tire Company, H. Walker Noyes Tire Co., Westbrook, ME (September 1974).

Nuclear Industry 1979 — "U.S. Nuclear Power Plants: Construction Progress," Nuclear Industry, vol. 26, no.1 (1979).

OWHM 1974 — U.S. Environmental Protection Agency, Office of Water and Hazardous Materials. Development Document for Effluent Limitation Guidelines and New Source Performance Standards for the Steam Electric Power Generating Point Source Category, EPA, Washington, DC (1974).

Peters 1978 — Peters, Bradley, Vice-President, Maine Central Railroad, Bangor, ME. Telephone conversation (December 6, 1978).

Popovich 1978 — Popovich, Luke. "Of Mice and Men: The Troubles of 2,4,5-T," Journal of Forestry, vol. 76, no. 12 (December 1978).

Reardon 1978 — Reardon, Robert, Assistant Power Systems Manager, Great Northern Paper Company, East Millinocket, ME. Meeting (March 9, 1978).

Reed & Bryant 1978 — Reed, Tom, and Bryant, Becky. Densified Biomass: A New Form of Solid Fuel, Solar Energy Research Institute, Golden, CO (July 1978).

Robinson 1978 — Robinson, Preston, Chief Project Engineer, St. Regis Paper Company, Bucksport, ME. Meeting (March 15, 1978).

Rodemann 1978 — Rodemann, U.W. "Load Management Pays for Itself," Public Power, vol. 36, no. 6 (1978).

Rolfe 1978 — Rolfe, David, Plant Engineer, S.D. Warren Company, Westbrook, ME. Meeting (November 13, 1978).

Rolfe 1979 — Rolfe, David, Plant Engineer, S.D. Warren Company, Westbrook, ME. Telephone conversation (January 17, 1979).

Roskoski 1975 — Roskoski, J.P. "Differential Nitrogen Fixation in Wood Litter," Bulletin of the Ecological Society of America 56(12)(1975).

Ruane 1977a — Ruane, M. "Conversion of Solid Wastes," Appendix G of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (1977).

Ruane 1977b — Ruane, M. "Ocean Thermal Energy Conversion," Appendix D of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977).

Ruane 1977c — Ruane, M. "Storage of Energy," Appendix H of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977).

Rubel 1974 — Rubel, Fred N. Incineration of Solid Wastes, Noyes Data Corporation, Park Ridge, NJ (1974).

Saeman 1973 — Saeman, Jerome F. "Solving Resource and Environmental Problems by the More Efficient Utilization of Timber," in Report of the President's Advisory Panel on Timber and the Environment, President's Advisory Panel on Timber and the Environment, Arlington, VA (1973).

Saeman 1977a — See Section 3.12.

Saeman 1977b — Saeman, Jerome F. Strategies and Priorities in Using Wood to Alleviate Energy Shortages, Forest Products Laboratory, Madison, WI (1977).

Savage 1979 — Savage, Edward, School Superintendent, East Millinocket, ME. Telephone conversation (March 20, 1979).

Sax 1975 — Sax, N. Irving. Dangerous Properties of Industrial Materials, 4th ed. (New York: Van Nostrand Reinhold Co., 1975).

S.D. Warren 1978 — S.D. Warren Company. "Application for Air Emission License," submitted to Maine Department of Environmental Protection, Augusta, ME (1978).

Sherburne 1979 — Sherburne, Russ, System Planning Supervisor, Central Maine Power Company, Portland, ME. Telephone conversation (February 23, 1979).

Sherwood & Meadows 1978 — Sherwood, Larry, and Meadows, Dennis. The Fuel Requirements of a 50-Mw Wood-fired Electrical Generating Facility in Northern Vermont, DSD #106, Resource Policy Center, Thayer School of Engineering, Hanover, NH (1978).

Smith 1962 — See Section 3.12.

SPPP 1975 — Science and Public Policy Program. Energy Alternatives: A Comparative Analysis (Washington, DC: U.S. Government Printing Office, 1975).

SRI 1976 — Stanford Research Institute. Crop, Forestry, and Manure Residue Inventory: Continental United States, vol. 1, SRI, Menlo Park, CA (1976).

SRI 1978 — Stanford Research Institute. Preliminary Environmental Assessment of Energy Conversion Processes for Agricultural and Forest Product Residues, vol. 1, SRI, Menlo Park, CA (1978).

Swain 1979 — Swain, Elizabeth, Wood Fuel Program Director, Maine Audubon Society, Falmouth, ME. Telephone conversation (February 15, 1979).

Thomae 1978 — Thomae, Sally, Senior Research Associate in Pharmacology, Dartmouth College, Hanover, NH. Meeting (December 1, 1978).

Thomae 1979 — Thomae, Sally, Senior Research Associate in Pharmacology, Dartmouth College, Hanover, NH. Meeting (March 7, 1979).

Threshold 1977 — Threshold to Maine Resource Conservation and Development Project. Goals and Objectives, Fiscal Year 1978: Program of Action Short-term Plan, Supplement #6. Threshold to Maine RC & D Project, Portland, ME (1977).

Turner 1979 — Turner, Alan, Wood Energy Specialist, Vermont State Energy Office, Montpelier, VT. Telephone conversation (February 15, 1979).

UNH 1966 — University of New Hampshire Agricultural Experiment Station. An Economic Analysis of the Potentials of the Hardwood Industry in Northern New Hampshire, UNH Agricultural Experiment Station, Durham, NH (May 1966).

USFS 1976 — U.S. Department of Agriculture, Forest Service. The Feasibility of Utilizing Forest Residues for Energy and Chemicals, PB-258-630, National Technical Information Service, Washington DC (March 1976).

USGS 1967-1977 — U.S. Department of the Interior, Geological Survey. Water Resources Data for Maine, Water Years 1966-1976, Water Data Reports ME-66-1 through ME-76-1, USGS, Washington, DC (1967-1977).

Valley News 1978 — The Valley News, West Lebanon, NH (September 30, 1978).

Voss 1977 — Voss, George D. "Industrial Wood Energy Conversion," in Fuels and Energy from Renewable Resources, David Tillman, Kyosti Sarkanen, and Larry Anderson, eds. (New York: Academic Press, 1977).

Vumbaco 1978 — Vumbaco, J.A. "Conservation Brings Savings," Public Power, vol. 36, no. 6 (1978).

Waterflow 1977 — Waterflow, A. "Geothermal Energy Conversion," Appendix C of Alternative Electrical Energy Sources for Maine, MIT-EL 77-010, M.I.T. Energy Laboratory, Cambridge, MA (December 1977),

Wayne 1979 — Wayne, Warner, Chief Hydraulic Engineer, Stone and Webster Engineering, Boston, MA. Telephone conversation (March 5, 1979).

Webster 1979 — Webster, Gaylord, Business Manager, Office of the Superintendent of Schools, Lincoln, ME. Telephone conversation (March 19, 1979).

Welch 1978 — Welch, Patrick H., Environmental Protection Supervisor, Great Northern Paper Company, East Millinocket, ME. Meeting (March 9, 1978).

Whiteside et al. 1973 — Whiteside, R.E.; Chu, T.Y.; Cosby, J.C.; Whitaker, R.L.; and Winfrey, R. Weights and Dimensions: Some Economic Effects on Highways, National Cooperative Highway Research Report #141, Highway Research Board, Washington, DC (1973).

Williams 1974 — Williams, J. Richard. Solar Energy, Technology and Applications (Ann Arbor: Ann Arbor Science Publishers, 1974).

Zerbe 1978 — Zerbe, John I. "The Many Forms of Wood as a Fuel," American Forests 84(10) (1978).