IDAHO NATIONAL ENGINEERING LABORATORY

Biomass Alternative Fuels Program: Final Report

A Feasibility Study of the Commercial Production of
Densified Biomass Fuel at Klamath Falls, Oregon:
Final Report
August, 1982
Modoc Lumber Co.

MASTER

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A FEASIBILITY STUDY OF THE COMMERCIAL PRODUCTION OF DENSIFIED BIOMASS FUEL AT KLAMATH FALLS, OREGON: FINAL REPORT

August, 1982

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Prepared for
MODOC LUMBER CO.
Klamath Falls, Oregon

By
ELIOT ALLEN & ASSOCIATES INC.
Salem, Oregon

Under

U.S. DEPARTMENT OF ENERGY CONTRACT NO. DE-FG07-80RA50368

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1. INTRODUCTION

Executive Summary

This report summarizes an eighteen-month project concerned with the feasibility of commercially producing and marketing densified biomass fuel (DBF) in Klamath Falls, Oregon. The project was undertaken by Modoc Lumber Co. in cooperation with the U.S. Department of Energy.

The project began with assessments of local biomass resources which could serve as feedstock for a DBF plant, and the potential customer markets for DBF. Based on these analyses, a pilot densification plant was designed and installed for purposes of trial operations and evaluation. In addition, exploration for geothermal resources was conducted in order to confirm a suitable feedstock dehydration heat source. The results of this exploration, and of the pilot plant's trial operations, were then used to determine requirements for a commercial-scale DBF plant, and the feasibility of upgrading the pilot plant for commercial-scale operations.

The results of this work are summarized as follows:

- There are abundant amounts of biomass feedstock generated annually in the project vicinity (approximately 472,600 bone dry tons (BDT) of mill woodwastes; 290,000 BDT of logging residue; 57,000 BDT of municipal solid waste; and 71,000 tons of crop residue). However, the majority of these resources are either committed to more valuable competing uses, e.g. particleboard, or are not readily

available due to economic reasons. A major constraint to commercial-scale DBF production is obtaining long-term guarantees of feedstock availability at cost-effective prices.

- An 18-county market area, divided into three trade zones, with a total population of approximately 1 million persons and an annual average growth rate of 4%, is identified as presently having a total heating requirement of over 37×10^{12} Btu's per year.
- A short-term market for DBF in the project's local trade zone is identified as approximately 100 institutional and industrial boilers using approximately $5,600 \times 10^9$ Btu's per year. Within this market eight boilers are presently using 244×10^9 Btu's per year in wood pellet fuel which is shipped into the area from other trade zones.
- Customer awareness of DBF in general, and wood pellets in particular, is limited in the market area, but an opinion survey indicates favorable attitudes towards DBF if retrofit cost payback is satisfactory, e.g. less than 5 years, and a steady supply of DBF can be assured.
- A pilot plant for wood pelletization was installed and operated for a six-month trial period, resulting in satisfactory equipment performance and pellet production. Major constraints identified during trial operations were pellet sensitivities to high moisture content in feedstock; and higher than expected production costs (as high as \$54/ton), due in largest part to higher than expected electrical costs, which ranged from \$5 to \$12/ton depending on

production output.

- Geothermal resource exploration confirmed a 189°F bottom-hole temperature, but a low flow rate and budget constraints prevented further well development. Consequently, dehydration of feedstocks in a commercial-scale plant will require a conventionally-fueled dryer.
- A commercial-scale plant is estimated to require \$2.6 million in total capital costs, for approximately 30,000 tons per year of wood pellet production, at an expected production cost of \$30-40 per ton.

The project concludes with a determination to not fully commercialize the pilot plant at this time due to the following factors: poor economic conditions in the national economy in general, and the regional lumber industry in particular; the difficulty in obtaining long-term supplies of sufficient quantities of feedstock; and uncertainty over the ability of DBF sales to support the capital investment and financing costs required for commercial-scale operations.

Background and Acknowledgements

Modoc Lumber Co. operates a lumber mill in Klamath Falls, Oregon which is capable of producing 66 million board feet of lumber annually. This lumber is composed predominantly of Ponderosa Pine, with lesser amounts of White Fir, Douglas Fir, and Cedar.

Klamath Falls, shown in Figure 1, is an urban area of 36,000 persons, with an economy based on timber, agriculture, and retail trade respectively. The community's elevation is approximately 4,200 feet, with a predominantly cold and arid climate of 6,516 heating degree-days annually.

After initially investigating the alternative fuel potentials of its mill wastes (planer shavings and hogged fuel), Modoc Lumber Co. responded to the May, 1980 U.S. Department of Energy (USDOE) request for proposals for alternate fuel projects (Solicitation No. DE-PA01-80RA50185). The USDOE subsequently awarded a grant to Modoc Lumber Co. in September, 1980. The ensuing eighteen-month project has been directed by the following representatives of Modoc Lumber Co.: Thomas J. Shaw, President; Gil Hannigan, Executive Vice-President; Kurt Schmidt, Assistant Manager; Duane Moon, Purchasing Agent; Frank Burton, Plant Operator; and Ray Keller, Plant Technician.

The prime contractor for the project was Eliot Allen & Associates, Inc. of Salem, Oregon. Principal subcontractors included: Chemax, Inc.; East Side Electric Company; Ellis Construction Company; The Ellison Company; Geothermex, Inc.; R. McClung; E.E. Storey & Son Drilling Company; Wellons, Inc.; Willamette Geotechnical, Inc.; and G.F. Willson. Acknowledgement is also given for the assistance of R.A. Currier, Oregon State University.

Organization of the Project and Final Report

The project was organized into the six work elements shown in Figure 2, which are discussed in the following six sections of this report.

Figure 1

PROJECT LOCATION

Figure 2

PROJECT WORK PLAN

2. FEEDSTOCK RESOURCES

Overview

The project is located in a region which possesses abundant biomass resources which may be generally available as feedstock for densification and sale as industrial fuel. Because competing uses for these resources are expanding, their long-term availability, cost, and comparative energy values are critical to the feasibility of any commercial DBF operation. The major characteristics of these resources which will affect a DBF operation's feasibility are their physical form, purity, perishability, seasonal availability, heat value, moisture content, handling requirements, and competing uses for other products in other markets.

For purposes of this study these resources have been categorized as follows: lumber mill and secondary wood manufacturing residues; logging residue; and additional resources (crop residue, municipal solid waste). The estimated annual supply of these DBF feedstocks in Oregon is shown in Table 1. The basis for measuring moisture content and heating value in these resources is discussed in Appendix A; as used in this report, moisture content is measured on a wet basis, unless noted otherwise.

Lumber mill and secondary wood manufacturing residues are the shavings, bark, and sawdust generated as byproducts of wood processing. Logging residue includes limbs, tops, shatter, and rotten cull logs. Municipal solid waste is the residential, commercial, and industrial solid wastes generated by the community. Crop residues are straws, prunings, and shells. In addition, in some communities with sufficiently large animal feedlots, manure may

Table 1

ESTIMATED ANNUAL SUPPLY OF BIOMASS FUEL IN OREGON

<u>Fuel</u>	% of Oregon's Total Annual Biomass Fuel Supply	<u>10¹² Btu</u>		<u>10⁶ dry tons/yr</u>	
		<u>Used</u>	<u>Unused</u>	<u>Used</u>	<u>Unused</u>
Wood					
Mill Residues	26	73.1	8.5	4.3	0.5
Logging Residues	37	8.5	107.7	0.5	6.3
Pulping Liquor	14	44.4	0.0	3.0	0.0
Solid Waste	7	0.0	21.6	0.0	1.8
Crop Residues	16	0.0	49.5	0.0	3.3
Manures	1	0.0	2.5	0.0	1.0
Food Process Wastes	<u>1</u>	<u>NA</u>	<u>1.0</u>	<u>NA</u>	<u>.4¹</u>
TOTALS	100	126.0	190.8	7.8	13.3

¹ Wet wastes

Source: Oregon Biomass Task Force, 1980

represent a viable feedstock for generating methane; however, this project was concerned exclusively with biomass resources which could be densified into solid fuel.

Of these biomass resources, wood residues are considered to be the most important in terms of existing uses and near-term potential for densification. The energy uses of wood, which have usually been low-valued uses, must compete with other wood uses such as pulp chips and fiberboard. Table 2 indicates the comparative energy value versus competing product value of a recent year's wood residue volume in Oregon.

The availability of wood residues for energy uses is also clearly dependent on the region's overall economy and resulting market demands for housing and wood products.

Primary Wood Manufacturing Residues

Primary manufacturers are lumber mills which utilize timber as a raw material for the production of dimension lumber, veneer, and similar products. Wood residues are generated through debarking, sawing, and planing operations, at a general rate of 1-3 tons per thousand board feet of lumber sawed. For purposes of this study mill wastes are grouped into two categories: wet hogged fuel (40-50% moisture content), with a heating value of approximately 4,500 Btu's per wet pound, and a current market value of approximately \$ 8 per dry ton; and dry planer shavings and sawdust (10-15% moisture content), with a heating value of approximately 8,500 Btu's per dry pound, and a current market value of approximately \$18 per dry ton. A major characteristic of these latter wastes are their almost total allocation or commitment to existing competing uses, e.g. particleboard. The competing demands for mill

Table 2
COMPARATIVE VALUE OF WOOD FUEL & COMPETING USES

<u>Use</u>	<u>Volumes</u> (10 ⁶ BDT)	1979 Sale Prices (\$/BDT)	<u>Finished</u> <u>Value</u>
Pulp			
Chips & Residues	9.2	45	NA
Cull logs	<u>1.3</u>	51	NA
Total	10.5		\$750 million per 5 million tons of paper
Export Chips	2.6	43	\$112 million
Hogged Fuel	4.3	15	\$64.5 million

Source: Oregon Biomass Task Force, 1980

residues will be an important factor in any DBF facility.

Within 50 miles of Klamath Falls there are 11 large lumber mills, i.e. annual production greater than 10 million board feet, as well as several smaller milling operations. All these mills utilize soft wood as a raw material, predominantly Ponderosa and Lodgepole Pine, along with a small amount of White and Douglas Fir. The wood residues generated by these lumber mills are highly marketable, being used as raw material for fiberboard, particleboard, paper products, and other related applications. Many of these lumber mills have long-term contracts covering the sale or commitment of their residues for such applications.

Due to the competitive nature of the wood residue market and the proprietary requirements of business information, detailed data on the types and quantities of residues generated by these lumber mills was not readily available. However, based on other studies (SERI, 1980) and Modoc Lumber Company's familiarity with local lumber mills, an estimate of a typical lumber mill's residue production, per million board feet of lumber production, was calculated to be 210 BDT of bark, 430 BDT of chippable material, and 450 bone dry tons of fines.

These assumptions were verified against actual figures for Modoc Lumber Company's 1979 lumber production, when 62.8 million board feet of lumber was produced. This verification of the estimating methodology is shown in Table 3, where the estimated residue amounts are within 5% of actual production figures.

Table 3
COMPARISON OF ESTIMATED & ACTUAL RESIDUE PRODUCTION
BY
MODOC LUMBER CO., 1979

<u>Residue Type</u>	<u>Estimated Production¹</u>	<u>Actual Production</u>
Bark	13,200	13,800
Chippable Material	27,000	26,000
Fines	<u>28,300</u>	<u>27,800</u>
TOTAL	68,500	67,600

¹ Estimate assumes 210 BDT bark, 430 BDT chippable material,
and 450 BDT fines per MMBF of lumber produced.

Using this approach, estimated volumes of wood residues from other primary wood manufacturers in the Klamath Falls area were calculated as shown in Table 4.

Rather than being generated as distinct groups of bark, chippable material, and fines, lumber mill wood residue is typically generated as wet hogged fuel (50% sawdust and 50% bark fines), chips, and dry sawdust shavings. By applying the distribution of these categories for actual Modoc Lumber Co. production, to the volumes estimated in Table 4, an adjusted estimate of the local production of wood residues was made, making the assumption that 50% (dry weight) of the fines are in the form of dry sawdust and planer shavings, and that the remainder is in the form of wet sawdust which is combined with bark to form hogged fuel. Table 5 presents the adjusted wood residue estimates for the project area according to these ratios.

The dry sawdust and shavings are generally able to be used directly in a densification process. The hogged fuel and chips require drying to achieve a moisture content suitable for densification, e.g. 10-15%.

An additional group of primary manufacturers which are present in the project vicinity, but which were not included in the foregoing residue estimates, are the veneer and fiberboard mills of the area. These operations are subject to the same competitive influences and proprietary requirements as with lumber mills; however, no estimating methodology is readily available to calculate residue production by these latter types of primary manufacturers. Thus, the amounts of primary manufacturer residue shown in Table 5 are considered to be conservative values for the area.

Table 4

WOOD RESIDUE GENERATION BY
PRIMARY MANUFACTURERS IN THE PROJECT VICINITY

(Estimated average annual production)

<u>Primary Manufacturer</u>	<u>MMBF</u>	<u>% of Area Total</u>	<u>Bark (BDT)</u>	<u>Chippable (BDT)</u>	<u>Fines (BDT)</u>
Chiloquin Forest Products	20	4.5	4,200	8,600	9,000
D.G. Shelter Products	65	14.8	13,650	27,950	29,250
Modoc Lumber Co.	65	14.8	13,650	27,950	29,250
Loveness Lumber Co.	15	3.4	3,150	6,450	6,750
Thomas Lumber Co.	25	5.7	5,250	10,750	11,250
Weyerhaeuser Co.	<u>250</u>	<u>56.8</u>	<u>52,500</u>	<u>107,500</u>	<u>112,500</u>
TOTAL	440	100.0	92,400	182,200	198,000

Table 5

ADJUSTED PRIMARY WOOD MANUFACTURER RESIDUE GENERATION

<u>Residue Type</u>	<u>Annual Estimated Production (BDT)</u>	<u>Local Market Value (\$/BDT)</u> ¹
Hogged Fuel	191,400	8.33
Chips	182,200	65.00
Dry Sawdust & Shavings	<u>99,000</u>	18.00
TOTAL	472,600	

¹ As of September, 1981.

Secondary Wood Manufacturing Residues

Secondary manufacturers are woodworking plants which utilize lumber as a raw material for the production of goods, such as furniture, mouldings, and similar products. Wood residue is generated by milling, sawing, and planing operations which generally creates a relatively fine residue material. Because the majority of the raw material used by secondary manufacturers is kiln dried, the wood residues they generate are dry and generally well suited to densification.

Secondary manufacturers were willing to release the residue production information shown in Table 6. As with primary manufacturers, residue generation by secondary manufacturers is directly related to the overall economy and market demands for their products. In addition, as shown in Table 6, their residue output is in large part already allocated or committed to other uses.

Logging Residues

Logging residues are waste materials left in the forest after timber harvesting. These residues generally have a moisture content of 40-50% and a heat value of approximately 4,500 Btu's per pound. Quantities available per acre and costs for collection will depend on timber species, age, and topography. Competing product uses include pulp and fiberboard.

The Winema National Forest, bordering Klamath Falls, has Ponderosa and Lodgepole Pine logging activity on approximately 25,000 acres of land per year. Within this area, the residue left after logging, which is larger than 4 inches in diameter and longer than 4 feet, has been estimated as 11.6 bone

Table 6

WOOD RESIDUE GENERATION BY SECONDARY MANUFACTURERS
IN THE PROJECT VICINITY¹

<u>Manufacturer</u>	<u>Material</u>	<u>Estimated Annual Volume (BDT)</u>	<u>Availability</u>
Freemont Glass & Millworks	90% dry pine shavings, 10% formica.	56	Gives material to County Fairgrounds
Jeld Wen, Inc.	Dry Fiberboard shavings	NA	Trades/sells to Weyerhaeuser for \$13.00/BDT
Maywood Ind. of Oregon	Dry pine & fir chips-sawdust	1,050	Sells under 2 yr. contract to Weyerhaeuser at \$10.00/BDT
Sturdi-Craft Furniture, Inc.	Dry pine sawdust	327	Sells on market for \$10.00/BDT; no long-term contract.
Henderson Millworks	Dry pine shavings sawdust	186	Sells to Weyerhaeuser under 2 yr. contract at \$6.50/BDT
Klamath Work Activity Center	Douglas fir sawdust and shavings	238	Gives material to County Fairgrounds
		<hr/>	
		TOTAL	1,857

¹ As of August, 1981.

dry tons per acre logged (Fuller, 1980). Using this approach, it is estimated that the Winema National Forest generates 290,000 bone dry tons of logging residue annually.

Estimated costs for harvesting, transporting, and chipping this residue in preparation for densification are summarized in Table 7.

Additional Biomass Resources

Three additional potential sources of DBF feedstock in the Klamath Falls area are municipal solid waste, agricultural residues, and the forest residue backlog. Municipal solid waste generally has a moisture content of 30-40%, and a heat value of approximately 5,000 Btu's per pound. Agricultural crop residues generally have a moisture content of 10-20%, and a heat content of approximately 7,500 Btu's per pound. (Oregon Biomass Task Force, 1980). Moisture and heat content in the forest residue backlog (previous logging residue and slash piles) is considered to be similar to current logging residue characteristics.

An estimated 30,000 tons of municipal solid waste is generated each year in the Klamath Falls urban area (Reid, 1981). All of this waste is currently landfilled at three County-operated disposal sites. Approximately 70% of the solid waste generated, or 21,000 tons annually, is densifiable biomass consisting primarily of paper and food wastes. However, before this material could be densified it would have to be separated from metal, glass, and other miscellaneous fractions of the total solid wastes. There exists, however, several point sources of densifiable wood and paper waste which may be utilized without the need for extensive separation activity.

Table 7

ESTIMATED COSTS TO PREPARE LOGGING RESIDUE FOR DENSIFICATION

<u>Item</u>	<u>\$/ton</u>
Collection & Loading	25
Transportation (approx. 50 miles)	10
Chipping	9
Drying	<u>10+</u>
TOTAL	\$54+

Source: after Fuller, 1980

In 1980 approximately 63,500 cubic yards of wood, in the form of brush, building demolition material, and wood chips, were landfilled at the County's disposal site in Klamath Falls. Also in 1980, another 54,000 cubic yards of paper waste from retail stores and similar outlets were landfilled at the Klamath Falls disposal site. The annual production of these potential solid waste feedstocks is summarized in Table 8.

Agricultural crops, such as hay and grain, are also abundant in the project vicinity, suggesting crop residues as an alternative feedstock. 1980 grain production within the project vicinity included 76,200 acres of barley; 18,700 acres of oats; and 12,900 acres of wheat; for a total of 107,800 acres dedicated to grain production. At an estimated one ton of waste straw per acre of grain, this local production represents a potential annual supply of 107,800 tons of densifiable biomass (Wilcox, 1981). However, this amount should be reduced by one-third to allow for plowback of residues into the soil for nutrient purposes every third year, leaving approximately 71,900 tons per year of densifiable crop residue available in the project vicinity.

It is estimated that crop residues could be baled at a cost of approximately \$13 per ton. The cost of transporting baled residue from the field to the densification plant varies by distance with an estimated range of \$5-10 per ton in the local area. The more conservative figure is used in Table 9. Residue harvesting and transportation costs may be lowered if densification were able to be performed in the field using a mobile plant.

A final alternative feedstock is the backlog of residue on the surrounding forests. These are residues generated by logging activities in the past which

Table 8

POTENTIAL FEEDSTOCK GENERATED BY MUNICIPAL SOLID WASTES
IN THE PROJECT VICINITY

<u>Feedstock</u>	<u>Annual Estimated Production (BDT)</u>
Densifiable Organic Waste	21,000
Wood Waste	21,400
Paper	15,000
Cardboard	<u>540</u>
TOTAL	57,940

Source: Klamath County Solid Waste Division

Table 9

LOCAL FEEDSTOCK COSTS SUMMARY¹

<u>Type of Material</u>	<u>Available (BDT/yr)</u>	<u>Purchase Collection Cost (\$BDT)</u>	<u>Trans- portation Cost \$BDT)</u>	<u>Chipping Cost (\$/BDT)</u>	<u>Drying Cost (\$/BDT)</u>	<u>Total Cost (\$/BDT)</u>	<u>Heat Content (10⁶ BTU/BDT)</u>	<u>Heat Cost² (\$/10⁶ BTU)</u>
Primary Manufacturers								
Hogged Fuel	191,400	8.33	3.00	-	10.00	21.33	16.0	2.05
Chips	182,200	65.00	3.00	-	10.00	78.00	16.0	7.50
Sawdust & Shavings	99,000	18.00	3.00	-	-	21.00	16.0	2.02
Secondary Manufacturers								
Sawdust & Shavings	1,860	18.00	3.00	-	-	21.00	16.0	2.02
Logging Activities								
Forest Residue	290,000	25.00	10.00	9.00	10.00	54.00	16.0	5.19
Other Sources								
Municipal Waste	21,000	-	3.00	-	-	13.00+	13.3	-
Wood Waste	21,400	-	-	9.00	5.00	14.00+	16.0	-
Paper	15,000	-	-	5.00	-	5.00+	16.0	-
Cardboard	540	-	-	5.00	-	5.00+	16.0	-
Agricultural Waste	107,800	13.00	10.00	-	-	23.00	15.0	2.35
Forest Backlog	110,688 ³	25.00	10.00	9.00	10.00	54.00	16.0	5.19

¹ As of August, 1982.² @ 65% efficiency.³ Ten year available forest residue.

have not been subject to fuels management activities and which, in some cases, represent a serious fire hazard in the forests. Currently the Winema National Forest estimates that backlog fuels in the vicinity of the project total 1,106,880 bone dry tons (Gouette, 1981). Over a ten-year period, this amounts to 110,688 BDT per year. The expense involved in collecting backlog fuels would be comparable to that of the fresh logging residue discussed earlier.

Feedstock Summary

The costs associated with all types of feedstocks are summarized in Table 9.

3. MARKET ANALYSIS

Market Area and Sectors

Having identified feedstock resources suitable for densification into solid fuel, the next project element was concerned with identifying and characterizing customer markets for DBF. This process began with the establishment of the trade zones shown in Figure 3 and described in Table 10. These zones were configured to correspond with surrounding population centers and typical trucking distances for fuel commodities.

The economies of these trade zones are uniformly dependent on timber, agriculture, tourism, and retail trade respectively. Demographic trends in all zones indicate continuing but slowing growth trends over the next twenty years. It is expected that the trade areas in California will grow at a slightly slower rate than those in Oregon.

A notable characteristic common to all the zones is an over-dependence in the local economy on the forest products industry. As a result, cyclical fluctuations in the national and regional housing and lumber markets will not only affect DBF feedstock availability and prices in the vicinity, but also demographic and economic conditions generally, and customer fuel demands in particular.

Potential customers of DBF were grouped into two sectors: large-scale boilers (commercial, institutional, industrial), and residential stoves. The estimated heating requirements of the trade zones according to these sectors (except industrial) is given in Table 11.

Table 10

PROJECT TRADE ZONES BY POPULATION & GROWTH RATE

<u>Zone</u>	<u>Radius (mi)</u>	<u>State</u>	<u>County</u>	<u>1980 Population</u>	<u>1970-1980 Growth Rate(%)</u>
Local	0-25	Oregon	Klamath	59,117	18.2
Primary	25-100	Oregon	Jackson	132,456	40.1
			Lake	7,532	18.7
		California	Modoc	8,610	15.3
			Siskiyou	<u>39,732</u>	19.6
			Subtotal	188,330	
Secondary	100-200	Oregon	Crook	13,091	31.1
			Deschutes	62,142	104.1
			Douglas	93,748	30.7
			Josephine	58,820	64.5
			Lane	275,226	27.8
			Subtotal		
		California	Del Norte	18,217	24.9
			Humboldt	108,024	8.4
			Lassen	21,661	29.0
			Shasta	115,715	49.0
			Tehama	38,888	31.7
			Trinity	<u>11,858</u>	55.7
			Subtotal	<u>817,390</u>	
			TOTAL	1,064,837	

Table 11

ESTIMATED HEATING REQUIREMENTS OF TRADE ZONES BY CUSTOMER SECTOR

<u>Space & Water Heat Requirements¹ (10⁹ Btu/yr)</u>						
<u>Zone</u>	<u>State</u>	<u>County</u>	<u>Residential</u>	<u>Commercial</u>	<u>Institutional</u>	<u>Total</u>
Local	Oregon	Klamath	1,189	119	24	<u>1,332</u>
Primary	Oregon	Jackson	4,239	424	85	4,748
		Lake	241	24	5	270
	California	Modoc	276	28	6	310
		Siskiyou	1,271	127	25	<u>1,423</u>
					Subtotal	6,751
Secondary	Oregon	Crook	419	42	8	469
		Deschutes	1,989	199	40	2,228
		Douglas	3,000	30	6	3,036
		Josephine	1,882	188	38	2,108
		Lane	8,807	880	176	9,863
	California	Del Norte	583	58	12	653
		Humboldt	3,457	346	69	3,872
		Lassen	693	69	14	776
		Shasta	3,703	370	74	4,147
		Tehama	1,244	124	25	1,393
		Trinity	379	38	8	<u>425</u>
					Subtotal	<u>28,500</u>
					Total	36,438

¹ Industrial requirements not available.

Potential customers within each sector were identified through surveys of government institutions, industrial manufacturers, and boiler licensing. A sampling of specific boiler data collected for the trade zones is given in Appendix B. This process resulted in the identification of immediate and near-term customers in the local zone amounting to approximately 1.3×10^{12} Btu's per year (or 76,500 tons of DBF per year).

Adjusted market potentials for the primary and secondary trade zones were not calculated beyond those values shown in Table 11. This was due primarily to the transportation cost penalty estimated at approximately \$13.40 per ton of DBF in the primary zone (25-100 miles), and \$18.00 per ton in the secondary zone (100-200 miles). Transportation cost estimates for all three zones are detailed in Table 12.

Under the assumption that competing densification enterprises are likely to operate in the outer fringes of the secondary trade zone, it was expected that secondary zone transportation costs would render any marketing attempt by Modoc Lumber Co. noncompetitive.

The primary zone transportation cost was considered a significant price penalty to potential buyers. Market penetration in the primary zone will also be dependent upon competing DBF enterprises, and additional measures such as back-hauling feedstock from product deliveries.

The subsequent focus on the local trade zone regrouped customers into three categories: boiler operators already using densified wood pellet fuel (the

Table 12

TRADE ZONE TRANSPORTATION COST ESTIMATES¹Local Zone (25 mi.)

Loading and unloading, 1 hr.	\$ 60
Travel time, roundtrip, 1.5 hrs.	<u>90</u>
	= \$5/ton

Primary Zone (25-100 mi.)

Loading and unloading, 1 hr.	\$ 60
Travel time, roundtrip, 5.7 hrs.	<u>342</u>
	= \$13.40/ton

Secondary Zone (100-200 mi.)

Loading and unloading, 1 hr.	\$ 60
Travel time, roundtrip, 8 hrs.	<u>480</u>
	= \$18/ton

¹ Based on contract trucking quotes as of April, 1981
of \$60/hr for a 30-ton load.

County School District, the Municipal Airport, and an asphalt manufacturing plant); other boiler operators with potential for retrofitting for DBF; and existing and potential residential consumers of DBF. The near-term market potential of these groups is summarized in Table 13.

Estimates of current sales to existing wood pellet consumers are given in Table 14 according to aggregated monthly consumption. In addition, two existing consumers are planning expansions which, as shown in Table 14, will increase the retrofitted local market by 4%.

Assuming that commercial-scale DBF production would range from 1,510 tons per month (1 shift per day) to 3,020 tons per month (2 shifts per day), the potential for near-term penetration of the local trade zone by a commercial-scale plant can be seen in Table 15. This indicates that the local trade zone will shortly have the capacity to absorb an average 86% of the DBF production from a 1-shift per day commercial-scale plant, or 43% of a 2-shift per day production schedule.

In addition to existing consumers of wood pellets, four large-scale boiler operators were identified in the local trade zone as prospective candidates for conversion to DBF. These prospective customers' attitudes towards such a conversion are discussed in a section below; their combined total heating requirements are estimated to be 150 billion Btu's per year (or 8,825 tons of DBF).

Table 13

ESTIMATED NEAR-TERM DBF MARKET POTENTIAL OF LOCAL TRADE ZONE

Current Wood Pellet Users in the Local Zone

<u>Users</u>	<u>No. of Boilers</u>	<u>Estimated Heat Requirement (10⁹ Btu/yr)</u>
Klamath County School District	6	38.2
Stukel Rock & Paving	1	99.9
Municipal Airport	1	106.2
Residential Customers (5)	NA	.5
Greenhouse	<u>1</u>	<u>-</u>
Total	8	244.3

Current Boiler Operations in the Local Zone

<u>City</u>	<u>No. of Boiler Operators</u>	<u>No. of Boilers</u>	<u>Total Estimated Heat Requirement (10⁹ Btu/yr)</u>
Klamath Falls	59	90	5,595
Bonanza	2	4	6
Merrill	4	4	10
Malin	<u>2</u>	<u>2</u>	<u>5</u>
Total	67	100	5,616

Table 14

ESTIMATED 1981 WOOD PELLET SALES IN THE LOCAL TRADE ZONE

<u>Month</u>	<u>Current Consumption (tons)</u>	<u>Projected Consumption with Planned Retrofits (tons)</u>
January	1,112	1,281
February	1,037	1,206
March	822	923
April	753	821
May	758	814
June	1,192	1,248
July	1,088	1,088
August	1,150	1,150
September	1,425	1,493
October	1,662	1,763
November	1,927	2,096
December	<u>1,952</u>	<u>1,617</u>
Total	14,878	15,500

Table 15

COMMERCIAL-SCALE DBF PRODUCTION AS A PERCENTAGE
OF THE NEAR-TERM LOCAL DBF MARKET

<u>Month</u>	Estimated Near-Term DBF Consumption In Local Market (tons)	% of 1-Shift DBF Production ¹	% of 2-Shift DBF Production ²
January	1,281	85	43
February	1,206	80	40
March	923	61	31
April	821	54	27
May	814	54	27
June	1,248	83	42
July	1,088	72	36
August	1,150	76	38
September	1,493	99	50
October	1,763	117	59
November	2,096	139	69
December	<u>1,617</u>	107	54
Total	15,500		

¹ 1510 tons/month.

² 3020 tons/month

Competing Fuels

The available fuels which DBF must compete against in the market area include: coal, directly combusted wood waste (hogged fuel), oil, natural gas, propane, and electricity. The current prices for these fuels in selected cities within the trade zones are given in Table 16, indicating a market area cost of competing fuels ranging from \$12.09 to 13.90 per million Btu. Prior to this project, it was estimated that a \$2 million commercial-scale DBF plant annually producing 45,000 tons of DBF, would have a delivered product cost of \$2.35-2.65 per million Btu (or \$40-45 per ton) (Oregon Biomass Task Force, 1980).

The lack of a major coal market share, with its attendant favorability for DBF retrofitting, will likely mean a slower market penetration rate as a result of the higher retrofitting costs generally associated with oil and gas boiler systems.

Alternative Types of DBF and Retrofit Requirements

Having identified potential customers and competing fuels in the market area, the next consideration was the type of DBF best suited for such a market, and the retrofitting requirements generally associated with each type. For the purposes of this project the following five types of DBF processes and products were evaluated for overall marketability:

- Pelletizing: This process uses a hard steel die perforated with a dense array of holes generally 1/4 inch in diameter. The die rotates against inner pressure rollers forcing the feedstock into the die with pressures in the 10,000 psi range.

Table 16
COMPETING FUEL COSTS & ESTIMATED MARKET SHARES IN SELECTED
TRADE ZONE CITIES¹

<u>City</u>	<u>Oil²</u>		<u>Gas²</u>		<u>Coal²</u>		<u>Electricity³</u>	
	Cost (\$/MMBtu)	Market Share(%)	Cost (\$/MMBtu)	Market Share(%)	Cost (\$/MMBtu)	Market Share(%)	Cost (\$/MMBtu)	Market Share(%)
Klamath Falls	12.45	35	9.22	24	2.65	2	13.28	27
Medford	13.02	38	9.22	14	NA	2	13.28	37
Bend	13.57	35	8.66	24	NA	2	13.28	27
Yreka	12.09	38	NA	NA	NA	NA	13.90	37

¹ As of February, 1982; market shares derived from Lund, 1980.

² Assumes 65% efficiency

³ Assumes 100% efficiency

The resulting pellet is extruded through the die and broken off at desired lengths generally ranging from 1/2 to 1-1/2 inches.

- Cubing: This is essentially a modification of pelletizing which produces larger cubes generally ranging from 1 to 2 inches in diameter.
- Briquetting: This process forces feedstock between rollers with cavities producing a densified product similar to charcoal briquettes.
- Extrusion: This process uses a screw to force feedstock into a die which forms large cylinders ranging from 1 to 4 inches in diameter. Binding agents may be added to increase the structural strength of these products, as well as to improve heat content. Extruded logs are widely marketed under the generic name "presto-log."
- Rolling-Compressing: This process, which is used primarily in agricultural applications, uses rotating shafts to wrap feedstock into cylindrical rolls ranging from 5 to 7 inches in diameter, with lengths between 3 and 8 inches.

Major considerations in evaluating the marketability of these DBF products included: the established pellet customer base in the local trade zone; the technological experience and costs associated with each process/product; and the retrofitting requirements generally associated with converting new

consumers to the products.

Extruded logs were eliminated from further marketing considerations in view of their established production and widespread availability throughout the market area, and their primary use in residential applications (these products presently retail in Klamath Falls at approximately \$127 per ton or \$3.73 per million Btu's).

With respect to retrofitting requirements, the technology for burning DBF as either a replacement or supplement to coal is well developed. Suspension and spreader stoker coal-fired systems can generally convert to DBF with a minimum of modification. Systems specifically designed to burn wood, such as fluidized bed combusters, small fire-tube boilers, bark-burning boilers, and vortex combusters, are presently in use or available in a wide range of capacities and multi-fuel firing capabilities. Residential wood stoves or fireplaces can be retrofitted by means of commercially-available firebox adapters.

The equipment and costs required for customer retrofits will be extremely customer-specific, making any generalizations difficult. To date in the local trade zone, the retrofit costs incurred by small-scale (less than 10 million Btu's per hour) boiler operators have averaged \$6,594 per 1 million Btu of boiler capacity, with large-scale (greater than 10 million Btu's per hour) costs in the worst case reaching \$2,187 per 1 million Btu's of capacity. Where customers had previously used coal, there were minimal requirements for changing air intake and speed of feedstock input. A summary of the retrofit experience of one of the largest wood pellet customers in the local trade zone, the County School District, is given in Table 17.

Table 17

SUMMARY OF KLAMATH COUNTY SCHOOL DISTRICT
WOOD PELLET RETROFITS

<u>School</u>	<u>Boiler Type</u> ¹	<u>Boiler Capacity (x10⁶ Btu/hr)</u>	<u>Retrofit Cost(\$)</u> ²
Chiloquin E.	Kewanee 80 hp	2.5	15,655
Chiloquin H.	Birchfield 180 hp	6.3	33,027
Bonanza	Kewanee 150 hp	6.3	56,467
Henley	Kewanee 150 hp	6.3	38,576
Merrill	Kewanee 80 hp	2.5	22,474

¹ Former fuel was diesel oil for all boilers except for residual oil at Henley.

² Retrofits performed during 1979-1981.

Source: Ellison, 1981

Payback periods for DBF retrofits are as difficult to generalize about as retrofit costs, being particularly sensitive to prior fuel efficiency and costs. In relatively simple retrofits, where the only major equipment requirements are a stoker, a flex auger for feedstock, and a fuel storage bin, capital costs of \$7-10,000 can be recovered in one to three years, depending upon local competing fuel costs (Spillman, 1981). The payback period for the Klamath County School District wood pellet retrofits described in Table 17 has averaged less than 12 months. Even with such quick paybacks, the School district has not allocated more monies for additional retrofits due to current economic conditions. Likewise many potential commercial and residential customers are constrained by currently poor economic conditions.

Market Attitudes

The potential customers identified in the local trade zone were surveyed by interview and written questionnaire in order to characterize market attitudes towards DBF in general, and pellets in particular (in view of the established local market in that particular form of DBF).

Interviews and questionnaires were completed with four large boiler operators in the local trade zone (three industrial enterprises and one local government organization). The combined DBF requirements of these respondents is approximately 300 tons per year, or 5 billion Btu's per year. Their present boiler fuel is predominantly gas, followed by oil. The estimated remaining useful life in their boiler equipment is an average of 15 years.

Generally speaking, the respondents had sufficient prior knowledge of wood pellets in order to make a retrofit decision. Most of the respondents had not

made a feasibility study of the application of pelletized wood to their boiler systems. However, the respondents unanimously felt that their companies would conduct such a study if a firm production source of such fuel was available locally.

Despite the limited, but nonetheless well publicized, existing local market for wood pellets, only one of the respondents was familiar with local use or others elsewhere in the country.

All respondents indicated a willingness to seriously consider using wood pellets if such use was successfully demonstrated by other enterprises in the area. They indicated that such consideration, as well as financial planning, would require an average of six to twelve months in the respondents' companies, in order for a pellet retrofit decision to be made.

If the payback period for the capital investment required by pellet retrofitting was assumed to be acceptable, the respondents indicated a strong willingness to invest as much as \$50,000 in retrofit costs, and in some cases up to or more than \$100,000. When asked what an acceptable maximum payback period would be for such a capital investment, answers ranged from 4 to 5 years.

A copy of the survey instrument which was used is contained in Appendix C.

In addition to the prospective conversion of these and other local boiler operators, it was noted that one of the existing consumers of wood pellets locally was preparing to expand its current consumption approximately 50%.

Marketing Strategies

Based on these market investigations, several preliminary marketing strategies were developed for evaluation during the pilot plant's trial operations. These strategies were as follows:

- The feedstock to be used for market entry would be dry planer shavings, considered to be a high quality (clean and low in moisture content) and internally available resource. Secondary emphasis would be given to hogged fuel, and the additional handling and dehydration requirements associated with it.
- The form of DBF product would be the wood pellet, in view of: its established market in the local trade zone; its increasing acceptance among other users throughout the region; its applicability to several market sectors (commercial, institutional, industrial, residential); its environmental soundness; and its expected cost competitiveness with competing fuels.
- Market entry would be attempted solely in the local trade zone to avoid the transportation costs of \$13-18 per ton for the primary and secondary zones. Entry into the outer zones would be dependent upon: the outcome of pilot plant trial operations; availability of cost-effective feedstock resources in quantities sufficient for commercial-scale production levels; successful geothermal resource exploration for

feedstock dehydration; and a final commercialization decision as to whether the pilot plant should be upgraded to commercial-scale production.

- Sales marketing in the local trade zone would be focused primarily on existing large-scale wood pellet users in order to establish successful sales and operating experiences as rapidly as possible. Sales would be pursued with existing residential pellet consumers and other potential users as production allows.
- The balance of the feasibility study would be concerned with optimizing product quality and production techniques through pilot plant trial operations, and exploration for a geothermal resource capable of dehydrating commercial-scale quantities of additional feedstocks.

It was expected that these strategies would result in a penetration rate of the local trade zone at approximately 5-10% of the market per year, during the first 2 to 3 years of sales, after which the penetration rate for the balance of the local zone, as well as the two outer zones, would be largely dependent upon the availability of cost-effective feedstocks and competing DBF enterprises.

4. PILOT PLANT

Design

The location of the pilot plant, as proposed to USDOE by Modoc Lumber Co., was in an existing one-story masonry and wood structure in the northeastern corner of the Company's 50-acre lumber mill in downtown Klamath Falls. The pilot plant's site plan is shown in Figure 4. This structure, contributed by Modoc Lumber Co. to the project, was considered favorable for the pilot plant in view of its proximity to the Company's mill residues; proximity to the Company's existing steam generating plant (in order to preheat feedstock prior to densification); good access to arterial streets for trucking; and suitable sites for construction of exterior components such as storage bins and a hammermill building.

Design of the pilot plant's components was approached by assessing the state of the DBF art in the literature, by inspecting operational DBF plants in other cities, and by conducting a comparative technical evaluation of the major pieces of equipment commercially available for wood pelletization.

The state-of-the-art assessment revealed five major types of densification processes and products. Several of these had origins in agricultural applications, but with recent increased interest in densifying wood and other biomass for fuel, the equipment utilized in densification has been modified accordingly. The state-of-the-art assessment included the identification and contacting of the suppliers of DBF equipment listed in Appendix D.

Figure 4

PILOT PLANT SITE PLAN

In addition to the literature survey, site visits and inspections were made at two DBF facilities: a wood pelletization plant under construction at Yreka, California, and an operating wood log extrusion plant in Lakeview, Oregon. These inspections and interviews with plant operators provided further information on equipment and costs, construction and operating histories, and marketing experiences.

Finally, a detailed comparison of the major types of densification machines was conducted to evaluate the relative merits of pelletizing machines versus briquetters, cubers, and extruders. The results of this survey are summarized in Table 18.

Based on the literature survey, plant inspections, and the equipment survey, the pilot plant's design and equipment choices were finalized as shown in generalized schematic form in Figure 5. Preference was given to equipment which had widespread previous operating histories in similar applications. Specifically, the California Pellet Mill Series 7122 system (pellet mill, cooler, motors) was selected due to its favorable capacity to cost ratio, and rapid delivery time.

The pilot plant's operation begins with planer shavings being moved by truck from the Company's planer mill to the pilot plant site. These shavings range in size from approximately $1/32$ to $1/2$ inches in length and have a moisture content of approximately 8 to 22%, depending upon climatic conditions. The planer shavings are unloaded into an air-driven handling system which blows them into a storage bin (Bin No. 1). The feedstock is then conveyed to a

Table 18

SUMMARY OF MAJOR DENSIFICATION EQUIPMENT FEATURES

A. PELLITIZERS

These systems use a perforated hard steel die which rotates against hard steel rollers. The feedstock is forced through the die at approximately 10,000 psi, forming the pellet.

1. Model	36-300 Pellet Mill
Manufacturer/Distributor	Sprout Waldron, Muncy, Pennsylvania
Production Capacity	5 ton/hr.
Power Requirement	300 HP
Delivery Time	16-18 weeks
Parts Supply	Muncy, Pennsylvania
System Cost ¹	\$80,000

2. Model	Series 7000 Pellet Mill
Manufacturer/Distributor	California Pellet Mill, Portland, Oregon
Production Capacity	5 ton/hr.
Power Requirement	250 HP
Delivery Time	9 weeks
Parts Supply	Sparks, Nevada
System Cost ¹	\$80,400

3. Model	Century Pellet Mill
Manufacturer/Distributor	California Pellet Mill, Portland, Oregon
Production Capacity	1 ton/hr.
Power Requirement	100 HP
Delivery Time	9 weeks
Parts Supply	Sparks, Nevada
System Cost ¹	\$40,700

Features: Widespread use of this machine for both wastewood and agricultural applications mean availability of parts, established expertise and the possibility of buying used equipment at a savings. The advantage of producing a product in a form familiar to potential customers and compatible with their fuel handling systems should not be overlooked.

Pacific Northwest Installations: California Pellet Mills are currently producing wood pellets in Brownsville and Hines, Oregon, as well as Burney, California. A Sprout-Waldron system has been installed in a plant in Yreka, California.

Table 13 continued

B. BRIQUETTERS

These systems compact the feedstock between counter-rotating pocketed rollers to form a briquette. The design minimizes friction which lessens machine wear and product temperature.

1. Model	WP-50 Roll Briquettor
Manufacturer/Distributor	Ferro-Tech., Wyandotte, Michigan
Production Capacity	1 ton/hr.
Power Requirements	25 HP
Delivery Time	14-16 weeks
Parts Supply	Wyandotte, Michigan
System Cost ¹	\$100,400

2. Model	WP-150 Roll Briquettor
Manufacturer/Distributor	Ferro-Tech., Wyandotte, Michigan
Production Capacity	6-8 ton/hr.
Power Requirement	140 HP
Delivery Time	14-16 weeks
Parts Supply	Wyandotte, Michigan
System Cost ¹	\$200,000

Features: By compacting the feedstock between rollers rather than through a die, friction and temperature buildup is minimized. This results in a lower power requirement and lower maintenance costs. Low exit temperature for the product eliminates the need for a costly cooling system.

Pacific Northwest Installations: There are no presently operating or planned briquetting systems densifying woodwaste in the Pacific Northwest. A similar system is being used by the Kingsford Company of Springfield, Oregon to manufacture charcoal briquettes.

C. EXTRUDERS

These systems use a piston ram to force the feedstock under high pressure (17,000 psi) into a die forming a large wood cylinder.

1. Model	FH 90/200C
Manufacturer/Distributor	Agnew Environmental Products, Grants Pass, Oregon
Production Capacity	1 1/2 tons/hr.
Power Requirement	75 HP
Delivery Time	30 days
Parts Supply	Switzerland
System Cost ¹	\$168,500

Table 18 continued

2. Model	90/200
Manufacturer/Distributor	SPM Corp.
Production Capacity	1 1/2 tons/hr.
Power Requirement	75 HP
Delivery Time	5 months
Parts Supply	Switzerland
System Cost ¹	\$168,800

Features: Designed specifically for woodwaste densifying. The product could be sold as a residential fuel.

Pacific Northwest Installations: Agnew Environmental Products has an operating system.

D. CUBERS

These systems are modifications of the pellet mill which produces cubes. It has been used primarily for agricultural and paper processing.

Recent field tests by the California Division of Forestry have shown this machine to be unsuitable for densifying wood wastes (Turner, 1981). Therefore, this system was been dropped from further study.

¹ Prices are F.O.B. Klamath Falls as of January, 1981.

Figure 5
PILOT PLANT
COMPONENTS & FLOW DIAGRAM

hammermill. In the hammermill the feedstock is ground by high-impact hammer action and particle screening to a material size of approximately 3/16 to 1/4 inches in size.

The properly-sized material is then blown by an air-driven system into a surge bin (Bin No. 2), where it is held prior to densification, thus providing a working margin to the flow of feedstock entering the pellet mill.

From the surge bin the feedstock is then conveyed directly to the pellet mill for densification. The pellet mill employs a densification chamber which receives the feedstock material and extrudes it through pellet dies. The feedstock may receive an injection of an additive designed to reduce mechanical friction, die wear, and particulate emissions from the plant, prior to entering the pellet mill. The additive may either be animal tallow or lignosite, which is an aqueous emulsified solution of calcium lignosulfonate and a petroleum hydrocarbon.

After the feedstock has entered the densification chamber, but prior to extrusion, steam may be injected into the chamber to preheat the feedstock, and thereby improve the binding of materials and further reduce die wear. The steam may be injected at approximately 30-125 lbs. of pressure, equaling approximately 353°F maximum temperature. The moisture content of the feedstock after steam injection ranges from 10 to 13 percent.

After preheating of the feedstock, the pellet mill densifies the feedstock material. The mill was initially equipped with three sizes of hard steel dies, with perforations ranging in size from 1/8 to 3/4 inches in diameter and

3 inches in thickness. The dies rotate against inner pressure rollers, forcing the feedstock into the die perforations at a pressure of approximately 10,000 psi. As the pelleted feedstock is extruded through the die perforations it is broken off in lengths ranging from 1/2 to 1 inches.

Extruded pellets leave the pellet mill at temperatures estimated to range from approximately 250°F to 300°F. Because of the exit temperatures the pellets are soft, fragile, and subject to breakage. The freshly extruded pellets have a moisture content of approximately 8 to 10 percent.

The pellets are conveyed from the pellet mill to a 10,000 cfm induced-draft cooler, which reduces their temperature to less than 100°F, and increases their hardness.

A bucket elevator carries the pellets from the cooler to a vibratory screener, which separates fines from pellets. The fines are then either be conveyed to a truck for delivery as a by-product, or are recycled into the raw feedstock flow for redensification.

After leaving the screener, finished pellets are conveyed and elevated into a product storage bin (Bin No. 3) to await shipment. The finished pellet has a moisture content of approximately 8 to 10%, a density of approximately 33 to 35 lbs. per cubic foot, and a heat content of approximately 8,500 Btu's per pound.

The pilot plant was also designed with a system of centralized controls which permits one person operation of the plant from the control room shown in Figure 5. This system includes remote control start/stop for all components,

bin level monitors, variable speed conveyor controls, pellet mill amperage meters, and instrumentation to test feedstock and product moisture content.

Procurement and Installation

Based on the foregoing design, the pilot plant components were procured and installed over the period of January-August, 1981. The major components, which were either purchased from manufacturers or fabricated on site by Modoc Lumber Co., are described in Table 19. Overall pilot plant costs are summarized in Table 20.

Installation work proceeded according to the following general sequence: the existing plant building was remodeled for placement of the pelletization machinery; soil bearing tests were conducted adjacent to the building in order to determine bin foundations requirements; a hammermill building was constructed as an extension of the existing plant structure (in order to isolate hammermill noise, vibration, and dust from other plant operations); and finally, bins and pelletization equipment were installed according to the layout shown in Figure 4.

Regulatory and Environmental Considerations

Prior to installation three government regulatory requirements were satisfied. A City of Klamath Falls Site Plan Review was conducted to allow construction of the pilot plant pursuant to zoning requirements; the City Hearing Officer's decision and findings on the pilot plant are contained in Appendix E. An Oregon Department of Environmental Quality construction approval was granted per the Notice of Construction contained in Appendix. Finally, the

Table 19
MAJOR PILOT PLANT COMPONENTS

<u>Component</u>	<u>Manufacturer</u>	<u>Size</u>	<u>Cost(\$)</u> ¹
Raw Materials Blower System	ROUTS	74 cf/hr	20,000
Raw Materials Bin (No.1)	Wellons, Inc.	10,200 cf	102,665
Raw Materials Conveyor	Fabricated on site	60 ft. x 26 in. (belt w/ bucket cleets	5,200
Stockpile Conveyor	Fabricated on site	33 ft. x 26 in. (chain type)	3,700
Hammermill	Champion Products	1800 rpm	11,052
Hammermill Air System	Champion Products	9000 cfs	15,284
Hammermill Conveyor	Fabricated on site	35 ft. x 26 in. (belt type)	856
Surge Bin (No. 2)	Fabricated on site	2600 cf	27,089
Fines Delivery Conveyor	Fabricated on site	70 ft. x 14 in. (belt type)	3,300
Fines Recycling Conveyor	Fabricated on site	25 ft. x 6 in. (belt type)	885
Pellet Bucket Elevator	Behlen Mfg. Co.	800 cfs	5,500
Pellet Mill	California Pellet Mill Co.	Series #7122-2	41,106
Pellet Screener	Rotex, Inc.	Model #210	7,076
Cooler Bucket Elevator	Shelby Mfg. Co.	700 cfs	4,827
Pellet Cooler	California Pellet Mill Co.	Series 5HRS	15,361
Cooler Blower	New York Blower Systems	8000 cfm	1,786
Pellet Conveyor	Fabricated on site	80 ft. x 14 in. (belt type)	4,300
Pellet Bin (No. 3)	MFS Corp.	4000 cf	7,426
Existing one-story masonry & wood building & property	Contributed by Modoc Lumber Co.	10,000 square ft.	<u>285,000</u>

¹ F.O.B. Klamath Falls, January-July, 1981.

Total \$562,413

Table 20
SUMMARY OF PILOT PLANT COSTS

Land and building	\$285,000 ¹
Equipment (from Table 19)	277,413
Labor	
Construction	24,272
Electrical	49,897
Professional services (engineering, marketing, legal, and management) ²	<u>72,400</u>
	\$708,982

¹ Estimated replacement value.

² Exclusive of geothermal-related expenses.

necessary electrical and building permits were obtained from the Klamath County Building Department.

Prior to installation of the pilot plant, ambient noise levels in the vicinity were recorded, ranging from 55 to 80 dBA, to establish baseline conditions for future monitoring of noise emissions from the plant. Noise data collected during the project is contained in Appendix G. Baseline air quality levels at the site were previously documented during Oregon Department of Environmental Quality permitting of the Company's lumber mill operations.

No substantive change in these levels was expected from pilot plant operations, as indicated by the Department of Environmental Quality's construction approval notice in Appendix F. Inasmuch as the pilot plant was installed within an existing lumber mill complex, and was designed to utilize existing mill or public utilities, no further environmental considerations were identified in connection with the pilot plant.

Patents

During the course of researching and planning this project a notable aspect of DBF manufacturing which became evident was the extensive historical and current patenting of various densification processes and products.

The patenting of DBF processes and products dates to 1880, when William Smith received Patent No. 233887 for "an improved fuel made from sawdust or other fragmentary waste products of sawmills," which was heated and compressed into "fuel." This was followed in 1926 by H. Holdaway in Patent No. 1580299, which covers "briquetting. . .wood material."

In 1959, Sprout Waldron & Co. engaged in a widely reported (and thus held to be in the public domain) project of densifying bark for boilers at the Southern Extract Company of Knoxville, Tennessee. In the 1960's, researchers from Oregon State University (R. Currier and J. Ricard) performed extensive densification experiments, culminating in a 1969 patent application which was denied on the basis that the process and products were considered well within the public domain.

However, in 1977, the U.S. Patent Office reversed itself and issued two pelletization process patents, No. 4015951 to R. Gunnerman for "fuel pellets...from organic fibrous materials;" and No. 4026678 to A. Livingston for densifying municipal waste into "fuel."

The most recent patents issued as of this writing were in 1980 to J. Dean and L. Wetzig for No. 4211740 covering "fuel pellets. . .from botanical materials;" and No. 4236897 to I. Johnston covering "fuel pellets."

In consideration of these patent claims, and the uncertainty as to the extent of information in the public domain, patent legal counsel was sought prior to start-up of the pilot plant. Based on this legal counsel and the plant design, it was determined that the Dean & Wetzig patent (No. 4211740) was the most applicable, and a license to operate the pilot plant under this patent was purchased by Modoc Lumber Co.

Trial Operations

The pilot plant was operated on a trial basis for a six-month period from

September, 1981 through February, 1982. During this period the plant's components were "debugged;" adjustments were made to bring components into balance with the overall system; experiments were conducted with various combinations of equipment settings and operating levels; and in the latter stages production output was test marketed in the local trade zone. The operating schedule during this trial period ranged from one to three days per week, using a single plant operator on an 8-hour shift, supplemented by two part-time maintenance technicians.

Feedstock utilized during the trial operations was limited to planer shavings (except for limited experiments conducted with bark). The major difficulty encountered with the feedstock was its moisture content, which would fluctuate according to outdoor climatic conditions, sometimes creating such high moisture contents, e.g. 20-25% that the shavings were unsuitable for pelleting without extensive preheating and/or recycling through the pellet plant. This was especially true during winter months.

Equipment performance during trial operations was generally satisfactory. Notable equipment experiences are summarized as follows:

- The raw feedstock storage bin has experienced some mechanical breakdowns in its cone agitator and feed auger, both of which have been corrected by new parts.
- During winter months raw feedstock was subject to freezing inside the storage bin, creating blockages in the feed system. The bin cone has now been enclosed and heated to reduce this problem.

- The placement of feedstock handling equipment on ground level has slowed clean-up of feedstock debris which accumulates around the equipment. This problem can be eliminated by installing handling equipment in an elevated position affording easy cleaning access.
- The hammermill has had difficulty grinding feedstock with high moisture content, e.g. greater than 20%. Adjustment of screen size (5/32 inch to 1/4 inch) has not appeared to have a substantive affect on performance.
- The preheating of feedstock with steam did not sufficiently heat the material because of delivery of steam considered to be too wet. This has been corrected with the installation of an expansion valve in the steam line.
- The pellet mill is subject to plugging when overloaded by feedstock input, requiring a careful balancing of conveyor speeds with moisture contents, and close monitoring of instrumentation and controls. Variable speed drive control on the main feedstock conveyor has been critical in controlling this problem. The only mechanical difficulty with the pellet mill to date has been the failure of bolts on the die chamber ring, which have required replacement on two occasions.
- Hammermill and pellet mill difficulties, as well as normal operating procedures, resulted in significantly higher

electric costs than expected. The difference was due to demand charges and not electrical energy consumed. Demand charges resulted in electrical costs ranging as high as \$12.00 per ton and never lower than \$5 per ton.

- The pellet screener required minor enlarging of its out-feed to prevent blockages which were occurring during heavy production output.
- The time required for loading of finished pellets into delivery trucks could be reduced from 45 minutes to 10 minutes for a 12-ton load by designing an elevated bin with a direct dump system; the pilot plant's space constraints required use of an auger feed from the bin into delivery trucks.

Production of pellets during the trial period was limited due to necessary "debugging" and equipment adjustments. Production output for the period is summarized in Table 21. These figures indicate that the plant operated at an average of 53 hours per month, and produced an average of 79 tons of pellets per month during the trial period. Hourly output from the pellet mill during the period ranged from a low of 1.5 tons per hour to a high of slightly over 5 tons per hour.

The pellet qualities during trial production were evaluated in terms of pellet size, strength, density, heat content, and moisture content. Table 22 summarizes the range of these characteristics during trial operations. These figures indicate that most qualitative characteristics were favorable, except for a shortness of length in the pellets, and a higher than expected fraction

Table 21

PILOT PLANT TRIAL OPERATION PRODUCTION SUMMARY

<u>Month</u>	<u>Days Operated</u>	<u>Total Hours Operated</u>	<u>Pellets Produced (tons)¹</u>
September	4	28	42
October	3	21	32
November	4	28	42
December	2	14	21
January	24	173	260
February	<u>21</u>	<u>201</u>	<u>373</u>
Total	58	465	770

¹ Production rates varied from 1.5 to 5 tons/hour as trial operations progressed.

Table 22

SUMMARY OF PELLET CHARACTERISTICS PRODUCED DURING
TRIAL OPERATION

<u>Month</u> ¹	<u>Average Size</u> <u>(Dia. x Length, in.)</u>	<u>Average</u> <u>Moisture</u> <u>Content(%)</u>	<u>Average</u> <u>Bulk</u> <u>Density</u> ²	<u>Average</u> <u>Heat</u> <u>Value(Btu)</u>
September	NA	6.0	34.3	NA
October	NA	8.9	33.5	8,667
November	1/4 x 3/4	10.1	33.2	8,767
December	1/4 x 1/2	8.0	32.4	8,421
January	1/4 x 1/2	7.9	30.7	8,254

¹ February data unavailable.

² In pcf.

of fines which require recycling for redensification. Detailed analyses of the pellet characteristics are contained in Appendix H.

Problems which arose with low hourly production and poor pellet quality were attributed to the high moisture content in the feedstock described earlier, and the need to improve feedstock preheating and thermoplastic bonding during pelletization.

The latter need was addressed by an experiment in February, 1982, when a bonding additive was introduced to the pelleting process. This process, marketed by Georgia Pacific Corporation as Lignosite (an aqueous emulsified solution of calcium lignosulfonate and petroleum hydrocarbon), was injected into the pellet mill mixing chamber in a 1% (by weight) solution. The results of a two-day test using this additive is shown in Table 23, indicating that, on a preliminary basis, the additive had positive effects on production. However, production costs also increased significantly.

In regard to the need for improving feedstock preheating, an expansion valve has been installed in the steam line to the pellet mill, in order to separate (flash) excess water in the steam, thus delivering higher preheating temperatures to the pellet mill. This refinement has resulted in marked increases in hourly production and higher product quality.

The production costs for trial operations were not considered to be indicative of typical operating costs, due to "debugging" and adjustments in the plant's operations. However, based on this experience and other studies, estimated

Table 23
BONDING ADDITIVE TEST RESULTS¹

<u>Test Situation</u>	<u>Production (tons/hr)</u>			<u>Quality</u>
	<u>Pellets</u>	<u>Fines</u>	<u>Total</u>	
No steam or additive	2.6	3.3	5.9	poor
Steam	3.5	3.5	7.0	good
Additive	3.7	2.0	5.7	fair
Both steam & additive	4.2	2.4	6.6	good

¹ Using a 1% solution of Georgia-Pacific Lignosite.

ranges of costs for a typical small-scale pilot operation are given in Table 24 (Reed, 1978; Fuller, 1980; Oregon Biomass Task Force, 1980). These figures provide the basis for commercial-scale economic assumptions discussed in Section 6.

During the last three months of the trial operations plant output was test marketed in the local trade zone. Limited donations and sales were made to two of the existing pellet consumers in the area, and to several residential customers. These donations and sales are summarized in Table 25. Informal surveys of these customers indicate a general satisfaction with the test product; however, it should be noted that these initial customers did not require especially high quality (i.e. longer length, higher density) pellets for their boilers, and a question remains as to the degree to which the pellet qualities must be improved in order to be suitable for all types of customers. In addition, it should be noted that the prices charged for these test sales were not indicative of typical production costs nor inclusive of profits.

Table 24

TYPICAL SMALL-SCALE PRODUCTION COST ESTIMATES¹

<u>Fixed Items</u>	<u>Estimated Cost (\$/ton)</u>
Land & building (15 yr. amortization)	1.30 - 2.60
Equipment (5 yr. amortization)	7.00 - 10.00
Patent license ²	-
Labor	4.00 - 6.00
Insurance	0.20 - 0.30
Property taxes	0.95 - 1.15
Bldg. maintenance	0.40 - 0.50
Professional services (legal, accounting)	0.20 - 0.36
Administrative overhead	0.40 - 0.60
Subtotal	14.45 - 21.51
 <u>Variable Items</u>	
Feedstock (planer shavings)	18.00 - 21.00
Electricity	5.00 - 8.50
Additives (optional)	0.75 - 1.50
Lubricants	0.05 - 0.09
Parts	1.00 - 2.50
Patent royalty ²	-
Subtotal	<u>24.80 - 33.59</u>
TOTAL	39.25 - 55.10

¹ Exclusive of patent expenses, profit, and business taxes. Production assumed to be 5,000 tons/year: one pellet mill; 4 ton/hr production; 7.5 hrs/day; 3 days/week (due to limited feedstock availability); 50 week/yr. Lack of feedstock dryer necessitates use of planer shavings.

² Costs dependent on specific patent and licensing agreement.

Table 25

SUMMARY OF TEST MARKETING DURING TRIAL OPERATIONS

Month	Tonnage Donated/Sold		
	<u>Residential Users</u>	<u>Commercial & Institutional Users</u>	<u>Industrial Users</u>
September	NA	38	4
October	NA	30	2
November	1	33	8
December	2	12	0
January	2	254	2
February	<u>3</u>	<u>268</u>	<u>2</u>
Total	8	635	18

5. GEOTHERMAL RESOURCE EXPLORATION

Geothermal Resources and Feedstock Drying

An early objective of the project was to investigate the feasibility of using geothermal energy as the heat source for commercial-scale feedstock dehydration and preheating. This objective was based on the plant site location within the Klamath Falls Known Geothermal Resource Area, as designated by the U.S. Geological Survey; and the expected cost savings in using geothermal heat rather than fossil fuels or combustion of a portion of the finished product to operate the dryer. A comparative summary of geothermal versus other drying methods is given in Table 26 (Dynamic Systems, 1981).

Resource Assessment

Geothermal resource assessment began with a geological investigation of the project site, then identification of favorable drilling sites, followed by exploratory drilling and resource testing. The goal of these activities was to confirm a geothermal resource of 150°F or greater, with a flow of 500 gpm or greater considered desirable.

The geological investigation revealed favorable structural and stratigraphic conditions beneath the project site, including possible fault traces in association with thermal anomalies as shown in Figure 6. Hydrological and temperature gradient data for the area reinforced the possibility of an underlying geothermal reservoir.

Table 26

COMPARATIVE SUMMARY OF FEEDSTOCK DRYING SYSTEMS¹
(16 tons/hr)

<u>Drying Method & Temperature</u>	<u>Capital Costs (\$ x10³)</u>		<u>Estimated Operating Costs (\$/ton)</u>				
	<u>Drying Equipment</u>	<u>Heat Source</u>	<u>Elect.</u>	<u>Maint.</u>	<u>Labor</u>	<u>Fuel</u>	<u>Total</u>
Geothermal, 200°F, Bed-type Configuration	530	63	0.81	0.52	0.78	NA	2.11
Wood Waste Fired, 285°F, Bed-type Configuration	410	70	0.57	0.93	0.78	2.93	5.21
Oil or Gas Fired, 285°F, Bed-type Configuration	410	70	0.52	0.73	0.78	10.00	12.03
Wood Waste Fired, 550°F, Rotary Drum Dryer	1,180 ²	200	0.29	1.12	0.98	2.93	5.32
Oil or Gas Fired, 550°F, Rotary Drum Dryer	1,180 ²	65	0.24	1.03	0.98	9.00	11.25
Wood Waste Fired, 285°F, Rotary Drum Dryer	994	190	0.32	0.51	0.78	2.93	4.54
Oil or Gas Fired, 285°F, Rotary Drum Dryer	994	75	0.30	0.47	0.78	10.00	11.55

¹ Used for initial study purposes only; final dryer cost estimates shown in Table 29 based on 9 ton/hr production.

² Includes \$780,000 wet stack scrubber.

Source: Dynamic Systems, 1981

Figure 6

GEOLOGICAL RECONNAISSANCE & RECOMMENDED GEOTHERMAL DRILLING SITES

RECONNAISSANCE GEOLOGY

- Q1 Alluvium, fluvial and lacustrine
- Ts Pliocene sedimentary rocks
- Tb Basalt flows
- Tob Older basalt

- Possible fault
- Drilling site

A complete copy of these investigations is provided in Appendix I. Their conclusions are summarized as follows:

- There was a good probability that aquifers exist beneath the project site capable of producing at least 500 gpm from depths between 1,000-2,000 feet.
- Temperature gradient data in the vicinity was limited, and consequently the depth at which temperatures would exceed 150°F was uncertain. Both anomalously high and low temperature gradients occur in wells in the immediate vicinity of the project site. A significant thermal anomaly occurs northeastward and may extend beneath the property.
- Drilling on the property should be located in the northeastern portion, as close to the possible fault traces as practical (see First and Second priority sites on Figure 6).

Drilling

Based on the foregoing conclusions, a test well was designed for location at Drill Site No. 1. This well was drilled during the period August-September, 1981.

A 17-1/2 inch diameter hole was drilled to a competent formation (black shale) at 317 feet. This depth was completely cased with 12-3/4 inch outside diameter by 1/4 inch thick surface casing, set and grouted. Drilling continued with a 8-3/4 inch bore to 1,105 feet, and then a 7-7/8 inch bore to

a bottom hole depth of 2,071 feet. During drilling an artesian flow of approximately 10-20 gpm of approximately 76°F water was encountered in a broken basalt formation beginning at 551 feet. Several minor cold water zones were encountered at 1,092, 1,380; and 1,900 feet. Artesian flow remained fairly constant during the remainder of the drilling, with fluid temperature increasing to a maximum wellhead of 82°F. Drilling was terminated at a total depth of 2,071 feet due to budgetary limitations, and a potentially promising temperature and flow in a fractured basalt zone at 1,912 feet.

Test Results

A pump test was subsequently performed over a 23-hour period, producing flows which ranged from 155 to 375 gpm, with 8-inch pump bowls set at 200 feet. Drawdown of the static water level varied from 111 to 195 feet, and temperatures at the wellhead ranged from 73 to 78°F. Final stabilized results included a maximum flow of 300 gpm, with 195 feet of drawdown and 74°F wellhead temperature.

Subsequent to the pump test, profiles of the well's temperature, gamma, spontaneous potential, and resistivity readings were made by the Oregon Department of Geology & Mineral Industries. The maximum bottom-hole temperature was 189°F at 2,064 feet. Summaries of these profiles and detailed drill cutting reports are contained in Appendix I. Overall exploration costs are summarized in Table 27.

Geothermal Summary

Based on these tests, it was concluded that the well could not produce a geothermal resource suitable for direct use in the dehydration or preheating

Table 27

GEOTHERMAL EXPLORATION COST SUMMARY

Geological reconnaissance and well siting	\$ 4,000
Well design and drilling contract preparation	2,000
Well construction	
Mobilization	1,100
Drilling	60,494
Casing	4,986
Cementing	5,460
Misc. completion	3,169
Pump testing	2,396
Geophysical logging	- ¹
Drilling supervision	<u>3,500</u>
	\$87,105

¹ Provided by the Oregon Department of Geology & Mineral Industries at no charge.

of feedstock.

Evidently the suspected faulting in the area had significantly influenced the local geology, such that impermeable stratas were preventing fluids from conveying the heat indicated by bottom-hole temperatures. The well encountered less than 25% basalt, with the majority of drill cuttings being silt stones, shales, and clays. These latter formations, due to low thermal conductivity, helped increase the temperature gradient between 1,200 and 1,900 feet. Unfortunately, low, if any, flows were encountered below the 600 foot level. The flow from the pump test is believed to have come from the artesian zone at the 550-600 foot level. Low permeability is also evident by the high drawdown during the pump test. The low wellhead temperature of this Table 27 test also indicated that very little, if any, fluid is available from formations below 600 feet.

These interpretations were concurred with by representatives of the Oregon Department of Geology & Mineral Industries, the U.S. Geological Survey, and the University of California Lawrence Berkeley Laboratory. All parties agreed that there is potential for encountering production zones at greater depths, inasmuch as it is not unusual for geothermal wells in the vicinity to encounter impermeable zones within proximity to producing zones. However, the high costs of deepening the well, together with the project's budgetary constraints, prohibited consideration of such deepening. Nonetheless, it is believed that the well, as completed, can serve as a suitable resource for other geothermal heat pump applications if not DBF. The capabilities of the well in conjunction with a water-to-water heat pump is summarized in Table 28.

Table 28

SUMMARY OF TEST WELL HEAT PUMP CAPABILITIES¹

	Well Flow		
	<u>100 gpm</u>	<u>200 gpm</u>	<u>300 gpm</u>
Peak Btu/hr output ($\times 10^6$)	1.7	3.3	5.0
Space heating capacity (sq. ft.)	67,000	133,000	200,000
Approximate heat pump system cost (\$)	80,000	135,000	160,000

¹ Assumes a 75°F geothermal fluid with 25°F ΔT through the heat pump, and a 135°F output with 10°F ΔT through the end-use.

Presently, evaluation of the drill cuttings and geophysical profiles is still underway through the technical assistance organizations cited above. However, because of the initial drilling results geothermal heat was eliminated from further consideration in a commercial-scale DBF plant.

6. COMMERCIAL-SCALE PLANT REQUIREMENTS

Design

Based on pilot plant trial operations and geothermal exploration, the conceptual design of a commercial-scale plant was developed. The objective of this design was to upgrade the pilot plant's capabilities from a maximum annual production of 8,400 tons (one mill producing 4-1/2 tons/hr, one shift per day), to approximately 30,000 tons per year (two mills producing 9 tons/hr, two shifts per day), in order to support market penetration in the balance of the local trade zone, and possible entry into the two outer trade zones.

The design for upgrading the pilot plant for commercial-scale production includes the components listed in Table 29, and depicted in Figure 7. The major features of this upgrading would include:

- Improvement of feedstock handling capabilities, to include a raw material truck and trailer, truck scale and dump, unloading shelter, additional storage bin, and various equipment monitors.
- A feedstock dehydration/preheating system, using a rotary drum dryer fired by either gas or DBF.
- An additional pellet mill and ancillary equipment.

Table 29

SUMMARY OF MAJOR COMMERCIAL-SCALE COMPONENTS
NECESSARY FOR PILOT PLANT UPGRADING
(9 ton/hr)

		Estimated Costs ¹
● PURCHASED PARTS		
Feedstock Storage Bin		\$ 261,600
Transfer Conveyors		16,500
California Pellet Mill System (Series 7122)		
Pellet Mill	\$ 55,390	
Drive Motor	13,740	
Mix Motor	1,970	
Dies	<u>13,500</u>	84,600
Feedstock & Pellet Handling Equipment		
Hammermill & Motor	\$ 21,980	
Truck Scale & Dump	121,670	
Unloading Shelter	13,470	
Monitoring Equipment	3,730	
Feedstock Truck & Trailer	140,000	
Raw Material Truck & Trailer	<u>215,600</u>	516,450
Rotary Dryer System ²		
Dryer Equipment	\$653,460	
Building Remodel	<u>50,000</u>	703,460
● SUBCONTRACTED ITEMS ³		
Foundation Construction		
Bin Foundation	33,950	
Truck Scale Foundation	24,250	
Truck Dump Foundation	42,040	
Paving	<u>21,350</u>	121,590
Equipment Installation		
Loading Area Lighting	1,000	
Electrical	25,000	
Metal Fabrication	<u>10,000</u>	36,000
Engineering & Construction Management		<u>135,000</u>
	TOTAL	\$1,875,200

¹ F.O.B. Klamath Falls, August, 1981.

² Excluding scrubber.

³ Parts and labor.

Figure 7

CONCEPTUAL COMMERCIAL SCALE DESIGN FOR UPGRADING PILOT PLANT

As noted in Table 29, the major expense in upgrading to commercial-scale would be the addition of a drying system. Rotary dryers are composed of a combustion chamber, dryer drum, and separator; they are available in single-pass and triple-pass types. Approximately \$3-5 per ton is the current cost estimate for a 600 horsepower dryer (Dynamic Systems, 1981; Willson, 1981). Detailed data on dryer requirements and performance expectations are contained in Appendix J.

Feedstock

The amount of feedstock required to sustain commercial-scale production would consume 100% of the Company's available planer shavings (8,000 BDT/yr), and approximately 93% of its available hogged fuel (25,750 BDT/yr).

The availability of such hogged fuel supplies is dependent upon several factors: the overall market demand for wood products and resulting levels of mill operations; the fuel and heat requirements of other mill operations, i.e. steam plant and dry kiln, which compete for the available hogged fuel; and contractual sales commitments to outside purchasers of hogged fuel, e.g. landscaping suppliers and other wood fuel consumers).

The ability to procure sizable quantities of feedstocks on a long-term basis from other mills in the area is doubtful due to the prior allocations or commitments discussed in Section 2, Feedstock Resources.

Environmental Considerations

The operation of a commercial-scale plant is not expected to differ markedly

in its environmental impacts from those associated with the pilot plant experience. If the pilot plant were to be upgraded to a commercial-scale the attendant regulatory requirements, including air quality maintenance, would be essentially the same as those applicable during pilot plant installation. Air quality in the vicinity would be affected by any combustion exhaust gases generated by the feedstock drying system.

Noise levels in the plant area would experience nominal increases due to the addition of several pieces of equipment. Occupational health and safety conditions would remain essentially unchanged from pilot plant conditions; a summary of pilot plant safety conditions are described in an insurance carrier report contained in Appendix K.

A commercial-scale plant's socioeconomic impacts on the community would include the economic value of local equipment purchases, the temporary construction labor force, the employee work force required for plant operations, and public costs and benefits accruing from the plant, e.g. public service requirements versus additional local government tax revenues). Of the approximate \$1.9 million in additional commercial-scale plant costs, it is estimated that approximately \$292,000 would be spent in the local economy. The construction labor and related professional service requirements for a commercial-scale plant are estimated to create a temporary local payroll of approximately \$190,000 over a twelve-month construction period.

It is expected that a commercial-scale plant would be staffed by a single operator per working shift (2 shifts per day), plus a general maintenance person on a quarter-time basis. Based on a two-shift operation, this employee work force would represent an annual payroll to the community of approximately

\$70,000 in wages and benefits.

A cost/benefit analysis of a commercial-scale plant's impact to community infrastructure indicates a significant net gain to the community. This is based on the plant's independent water system, its single lavatory and storm drain connections to municipal sanitary and storm sewers, and its proximity to adequate streets; posed against annual property tax revenues to local governments of approximately \$48,000 (based on 1981 local tax rates).

Marketing

The successful marketing of commercial-scale quantities of production, e.g. 30,000 tons or more annually, would require a nearly complete capture of the existing local pellet consumers, 100% increase in new conversions in the local zone, and possible entry into one or both of the outer trade zones. Moreover, this market growth would have to be accomplished in a very rapid period of time and at an increased product price in order to absorb the financial costs of commercial-scale plant investment and increased transportation costs.

It is expected that the marketing strategies discussed earlier would be refined or supplemented by the following strategies:

- A price discount strategy, which offers buyers a product of comparable quality to a competitive product at a lower price. For this strategy to work three assumptions must be fulfilled: first, the challenger must be able to convince buyers that its product is of a comparable quality to the competitor's; second, the buyers must be sensitive to the price difference and be able to terminate

existing purchase agreements; and third, the competitor must adhere to its original price in spite of the challenger's lower price.

- A product-innovation strategy may be applicable in the case of achieving new retrofits, where pellets could be marketed as innovative replacement fuel for higher priced fossil fuels, which are subject to fluctuations in supplies.
- An improved-services strategy could challenge the market leader by finding ways to better serve buyers when compared to competing services. This could include improved delivery routes and schedules.
- A manufacturing-cost-reduction strategy could also increase market shares by achieving lower manufacturing costs than competitors, thus enabling savings to be passed along to customers.
- An intensive advertising campaign could also be employed to stimulate customer awareness in the various market sectors and trade zones, either through personal contacts, mailings, or trade advertising.

Experience has shown that an enterprise rarely succeeds in achieving its market goals by relying on only one or two of these strategies. Rather, success depends most often on designing a comprehensive strategy that will improve the enterprise's market position over time.

Economics

Based on pilot plant trial operations and the commercial-scale equipment requirements described above, the economics of a commercial-scale plant were evaluated in terms of capital requirements, operation and maintenance costs, likely financing methods, and resulting life-cycle costs.

The pellet production assumptions used in this economic analysis were based on an hourly production of nine tons (4.5 tons per pellet mill), or 135 tons from two 7-1/2 hour shifts per day. This gives a weekly production total of 675 tons, or an annual total of 33,750 tons.

The economic assumptions used in the analysis are summarized in Table 30, including fixed and variable cost assumptions for the plant's first year of operation, and assumed escalation rates for a ten year life-cycle. The projected life-cycle costs for a commercial-scale plant are shown in Table 31. One hundred percent equity financing was assumed because of uncertain project financing sources. Calculation of taxes assumed a 52% combined federal and state tax rate; ownership of the capitalized property for its entire recapture period; and eligibility for federal business investment, energy investment, and nonconventional fuel source tax credits. A detailed discussion of the tax incentives applicable to the project is contained in Appendix L.

The results of this analysis indicate that the economics of commercial-scale production will be very site and time-sensitive, depending on the particular feedstock, market, and general economic conditions in a given situation. Cost factors which will have a major influence on commercial-scale economic feasibilities will include feedstock, electricity, parts replacement, patent

Table 30

ECONOMIC ASSUMPTIONS FOR A COMMERCIAL-SCALE PLANT

<u>Plant Component</u>	<u>Assumption/Estimate</u>	<u>First-Year Cost(\$)¹</u>
<u>FIXED</u>		
Equipment	\$2,266,782 amortized over 5 years	453,356
Patent Fee	\$25,000 amortized over 5 years	5,000
Land & Bldg.	\$285,000 amortized over 15 years	22,333
Plant Labor	Wages/benefits for 2 operators and part-time (.25) maintenance person	56,000
Admin. Overhead	3% of fixed costs	18,219
Insurance	0.5% of plant value	12,634
Property Taxes	\$19.04 @ \$1000/assessed valuation	48,586
Marketing	Advertising and promotion allowance	4,400
Prof. Services	Accounting and legal estimates	7,000
Bldg. Maintenance	\$150/month	<u>1,800</u>
Subtotal		629,328
<u>VARIABLE</u>		
Feedstock	Hogged fuel @ \$8.33/BDT	281,138
Electricity	\$3.61/ton	121,838
Additives	\$1.50/ton	50,625
Lubricants	\$0.09/ton	3,000
Parts	\$2.53/ton	85,388
Patent Royalty	2% of sales or \$1.10/ton	<u>37,125</u>
Subtotal		<u>579,164</u>
TOTAL		1,208,492

¹ Assumes 33,750 tons/year of production from two eight-hour shifts per day.

Table 31

LIFE CYCLE COST ANALYSIS

PRODUCTION 33750 TONS

INVESTMENT & ENERGY
TAX CREDITS 453356NONCONVENTIONAL FUEL
SOURCE CREDIT 296663

TOTAL CAPITAL COST 2588182

	1	2	3	4*	5	6	7	8	9	10	11
	SALES OF 33750 TONS @ \$55.00 PER TON	FEEDSTOCK & ADDITIVES	ELECTRICITY	OPERATION AND MAINTENANCE	INSURANCE AND PROPERTY TAXES	DEPRECIATION	NET INCOME BEFORE TAXES	FEDERAL AND STATE INCOME TAX	NET INCOME AFTER TAXES	NIAT PLUS DEPRECIATION + TAX CREDIT	DISCOUNTED CASH FLOW
YEAR ZERO AMOUNT	1856250	331763	121838	212932	61220						
YEAR											
1982	1986188	354986	131463	227837	62444	475689	733768	388897	344871	1570578	1044474
1983	2125221	379835	141849	243786	63693	475689	820369	434795	385573	1157925	512102
1984	2273986	406423	153055	260851	64967	475689	913001	483890	429110	1201462	353365
1985	2433165	434873	165146	279110	66266	475689	1012080	536402	475678	1248029	244105
1986	2603487	465314	178193	298648	67592	475689	1118051	592567	525484	1297835	168814
1987	2785731	497886	192270	319554	68944	17333	1689745	895565	794180	1108175	95860
1988	2980732	532738	209767	341922	70323	17333	1808649	958584	850065	1164061	66964
1989	3189383	570030	228855	365857	71729	17333	1935579	1025857	909722	1223718	46815
1990	3412640	609932	249681	391467	73164	17333	2071064	1097664	973400	1287395	32753
1991	3651525	652627	272402	418869	74627	17333	2215666	1174303	1041363	1355359	22932
TOTAL	27442056	4904644	1922681	3147901	683749	2465110	14317972	7588525	6729447	12614538	2588182

* Includes plant labor, administrative overhead,
marketing, professional services, building
maintenance, lubricants, parts, and royalty.

expenses, and debt service. Feedstock costs have the strongest influence on selling price, whereas major increases in capital investment only affect the selling price approximately 5-15%.

It should be noted that this economic analysis is exclusive of fuel costs to operate the feedstock dryer. At the time this analysis was prepared, geothermal exploration was not complete, and it was still hoped that geothermal heat would be available to operate the dryer. If the dryer were to be fueled with hogged fuel, additional variable costs of \$8.33/ton for the hogged fuel and \$2.93-5.00/ton for dryer operation and maintenance would be added to Tables 30 and 31. Hogged fuel costs may range higher than \$8.33/ton depending on the amount of hogged fuel which the Company would have to purchase from other mills, their costs per ton, and transportation costs from such mills to the Company's plant.

Financing

In addition to analyzing the economics of commercial-scale plant operation, a brief investigation was made of financing available for upgrading the pilot plant to a commercial-scale. Financing sources considered include:

- Company earnings designated for business reinvestment; the cost of this capital is assumed to be equivalent to the cost of a commercial loan.
- Conventional short-term loan from a commercial lender; interest rates for this type of financing have ranged from 15-22% during the course of the project.

- Traditional or leveraged leasing, where the plant would be financed and owned by an outside party and leased back to the Company, with a possible Company purchase at the termination of the lease; effective interest rates on such leases are presently ranging between 8-14%.
- Oregon Department of Energy Small-Scale Energy Loan Program, which makes low interest, e.g. 10-12%, loans financed by state general obligation bonds; this program was determined to be inapplicable to the Company requirement because of a small business limitation of 100 or less employees, which the Company exceeds.
- Oregon Department of Economic Development Industrial Revenue Bond Program, which offers tax-exempt low interest, e.g. 11-13%, loans for new or expanding businesses.
- Other Federal programs which have been historically available, e.g. EDA, FmHA, and DOE, were not considered in depth due to recent federal cutbacks in these programs.

The ability to obtain any of this financing will be largely dependent upon satisfactory economic analyses and sufficient guarantees of feedstock availability and customer purchases.

While the economics appear to be favorable, the ability to obtain large-scale, long-term feedstock commitments and firm customer contracts remains tenuous,

particularly during the poor economic conditions that are prevailing as of this writing.

7. COMMERCIALIZATION DECISION

Risks and Sensitivities

The final task in the project was an evaluation of the major risks and sensitivities identified, and a decision under the scope of the Company's agreement with USDOE as to whether the pilot plant should be upgraded to commercial-scale operations.

The major risks identified during the course of the project are summarized as follows:

- Feedstock supplies are subject to significant cyclical fluctuations as a result of changing demands in the housing and timber industries.
- Market demands for pulp and particleboard products are relatively inelastic, resulting in extreme competition for available feedstock supplies.
- While the market area is presently served by a limited number of DBF producers, because of the readily available technology and generally ample (though not necessarily available) feedstocks, there is a good probability of increased competition in the area in the years ahead.

- The risks of mechanical failure in connection with pelletization equipment are recognized, but not considered to be any greater than those historically associated with similar wood processing equipment; an exception may be the pellet mill itself, which does not yet enjoy a lengthy and widespread history of successful operation using other than agricultural feedstock.

The major sensitivities identified in the project are summarized as follows:

- The important economic sensitivities were: feedstock cost impacts on production costs; and other energy costs (pelleting electricity and possibly fossil-fueled drying).
- The major technological sensitivities included: the vulnerability of feedstock quality to climactic conditions when handled outdoors (e.g. higher moisture content in winter, frozen material in bins); and, most notably, the high sensitivity of feedstock moisture content as it relates to the thermoplastic bonding effects during densification, underscoring the need for either climactically-controlled feedstock handling systems and/or preheating of the feedstock prior to densification.

Commercialization Decision

The risks and sensitivities discussed above were then weighed in in order to arrive at a decision on upgrading the pilot plant to commercial-scale status. The major conclusions which are supportive of DBF production in general and commercial-scale wood pellet operations in particular are:

- Planer shavings appear to be available from Modoc's own operations in sufficient quantities to support moderate production levels, assuming that competing uses and commitments are not prohibitive. Approximately 8,000 tons per year of primary and secondary wood manufacturer residue should be available through Company and other sources on a reliable basis, and without need of dehydration (but still requiring preheating). Any feedstock requirements beyond these 8,000 tons will necessitate installation of a dehydration system.
- The market area is generally growing, and awareness of alternative fuels is increasing in proportion to the increases in competing fossil fuel prices. Wood pellets appear to have strong appeal in all market sectors (residential, commercial, institutional, industrial).
- The pilot plant's trial operations proceeded satisfactorily without a major failure or stoppage due to design or construction deficiencies. The plant is able to be operated adequately by one operator per shift, minimizing fixed labor and overhead costs.
- A commercial-scale plant would be expected to have no major technological difficulties, inasmuch as the commercial-scale equipment would be identical to that of the pilot plant, excepting for the dryer system, which has been proven in a variety of similar applications.

- The quantities of feedstock required for commercial-scale production do exist in the local trade zone, aside from the fact that they must be strenuously and expensively competed for. The availability of DBF feedstock should generally increase in the years ahead as forest residue collection techniques improve and land-fill disposal of municipal solid waste becomes more difficult and expensive.
- The economics of commercial-scale operations are such that economies of scale create lower production costs in proportion to higher production outputs, and subsequently offer more rapid payback and higher return on investments. In addition, tax incentives presently applicable to the project (three types of tax credits and accelerated cost recovery) make the project even more economically attractive.

Despite these positive conclusions, it was determined that the project would not be fully-commercialized at this time due to the following factors:

- The availability and cost of primary and secondary wood manufacturer residues are strongly affected by cyclical fluctuations in the economy in general and the housing and timber markets in particular. Moreover, there are numerous competing uses for feedstock, several of them for higher-value products, such as paper and particle board.
- The densification process is highly sensitive, in terms of production quantity and quality, to various feedstock characteristics such as moisture content and particle size, some of

which can only be controlled or mitigated through additional capital-intensive measures.

- The multiplicity and counterclaims of densification patents creates an ambiguous legal climate which tends to discourage business expansion and improvements in the densification industry.
- The project's market area is not densely populated, and any entry into its outer trade zones must overcome significant transportation costs. Also, as noted above, increased competition within the market area can be expected in the years ahead.
- Customer heating requirements are winter-biased, leaving poor sales conditions during summer months.
- The inability to confirm a moderate-temperature (e.g. greater than 150°F) geothermal resource denies a considerable capital and operating cost savings to the dryer required for any commercial-scale operation (requiring instead either a gas-fired system or internal consumption of pellets).
- It is doubtful whether the local trade zone could support the capital investment and financing costs required for commercial-scale operations, particularly in view of the difficulties which new customers would likely encounter in attempting to finance their retrofits during the current economic recession. It is expected that the sales required to support commercial-scale plant investment

would, in turn, require a virtual total capture of the local trade zone, which is improbable in the near term.

- The overall economics of commercial-scale operations appear to be especially sensitive to feedstock and electrical costs, creating a greater degree of risk in the project than is desired.
- The ability to finance commercial-scale operations in a cost-effective manner in the foreseeable future is questionable due to continued high interest rates, poor economic forecasts for the country in general, and the timber industry in particular.

The decision not to fully commercialize operations at this time is believed to be a prudent judgment in view of the results of this study and the poor economic conditions prevailing as of this writing. This decision will be subject to review as economic and financial conditions change over time.

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9. APPENDICES

Appendix A

WOOD MOISTURE CONTENT & HEATING VALUE MEASUREMENTS

Moisture content (MC) in wood is measured according to two bases: wet and dry. The wet basis is the weight of water in a wood sample divided by the weight of dry wood plus the weight of water:

$$\text{Moisture Content, \%} = 100 \frac{\text{weight of water}}{\text{weight of dry wood} + \text{weight of water}}$$

On this basis, a one pound sample which is found to be 1/2 pound wood and 1/2 pound of water upon drying and weighing has a MC of 50%.

The MC of wood on the dry basis is the fractional water content or the weight of water divided by the sample weight when dried:

$$\text{Moisture Content, \%} = 100 \frac{\text{weight of water}}{\text{weight of dry sample}}$$

Using the same example, a one pound sample which is half water and wood by weight would have a wet weight of one pound, a dry weight of one half pound, and a MC, dry basis of 100%.

To find wet basis from dry basis:

$$\text{Moisture Content, Wet} = 100 \frac{\text{MC Dry}}{100 + \text{MC Dry}}$$

To find dry basis from wet basis:

$$\text{Moisture Content, Dry} = 100 \frac{\text{MC Wet}}{100 - \text{MC Dry}}$$

The following conversion table covers the normally encountered range:

<u>Equivalent Moisture Content</u>	
<u>Wet Basis</u>	<u>Dry Basis</u>
0%	0%
5%	5%
10%	11%
15%	18%
20%	25%
30%	43%
40%	67%
50%	100%
60%	150%

The equilibrium water content of wood fuel varies with climate. Wood dries out naturally when left exposed to the air. Approximate average MC for wood which is not exposed to rainfall is 8%. The 8% figure corresponds to 45% relative humidity at 70°F.

The lower and higher heating value of wood (LVH and HHV, respectively) changes with its MC. The relationships between the higher heating value and MC (wet basis) follows:

$$\text{HHV (Btu/lb, actual)} = \text{HHV (oven dry)} (1-X)$$

where X is the fractional MC, wet basis. For example, a wood sample which has a HHV of 9,000 Btu/lb, oven dry, has a HHV of 4,500 Btu/lb at 50% MC, and 6,750 Btu/lb at 25% MC.

The HHV can be converted to LHV by the following formula:

$$\text{LHV} = \text{HHV} - 9,460 (X_{\text{H}_2}) - 1,059 (X_{\text{H}_2\text{O}})$$

where X_{H_2} is lbs of hydrogen per lb of wood (as received), and $X_{\text{H}_2\text{O}}$ is lbs of hydrogen per lb of wood (as received) found by ultimate analysis.

For a wood sample with ultimate analysis 50% water, 3% hydrogen, and HHV 4,500 Btu/lb @ 50% MC, the LHV is 3,687.

The HHV of a fuel is easily found in the lab using a bomb calorimeter. The LHV is more difficult to find as it assumes that the products of combustion are cooled to their initial temperature, but that the water vapor is not condensed. When comparing dry fuels with little hydrogen, fuel efficiency will not differ appreciably using LHV or HHV. The LHV is a better standard for comparing the true efficiency of high hydrogen fuels. The HHV, however, is the generally accepted standard because it is easily found in the lab.

Source: McGowan, 1979

Appendix B

SAMPLING OF BOILER DATA COLLECTED FOR TRADE ZONES

CODE

P - Power Boiler
M - Miniature/Spec.
C - Cast Iron
H - Low Pressure, Hot
Water, Steam
L - Large Opening
S - Small Opening

Name	Code	Diam	Area	Type	Pressure	H.P.
<u>CROOK COUNTY - Prineville 97754</u>						
Crook County Courthouse	HS	034	000500	Fire Box Return Tubular	0015	
Nursing Home	HS	042	000335	Dry Back Marine	0030	00006
Lythe Creek Distillery, Inc. Rt 1, Box 1295	PL	096	002500	FT	0150	00500
Ochoco Pellet Plant P.O. Box 296	PS	024	000026	Elec.	0100	00020
Pioneer Memorial Hospital P.O. Box 648	HS	036	000086	Vertical Tubular	0160	
City of Prineville 400 E. Third	HS	040	000270	Fire Box Return Tubular	0030	
	HE	000	000041	Water Tube	0160	00004
	HE	000	000041	Water Tube	0160	
	HE	000	000041	Water Tube	0160	
Les Schwab Tire Center P.O. Box 667	PS	020	000278	Water Tube	0125	00050
	PL	078	001750	FT	0160	00200
Crooked River Meat Co. Rt 1, Box 1004	PS	030	000142	FT	0163	
<u>KLAMATH COUNTY 97601</u> (Klamath Falls except where noted)						
Alameda Nursery & Greenhouses 853 S. Alameda	HS	024	000088	FT	0015	
BPOE #1247 25 Hawkins St.	HS		000500	Water Tube	0125	
	HS	032	000065	Coil	0030	
	HS	032	000065	Coil	0030	
Bible Baptist Church 2244 Wiard St.	HS	012	000193	Water Tube	0150	00020
Crater Lake Lodge	HS	048	000045	FT	0125	00009
Crater Lake, 97604	HS	040	000030	FT	0100	00006
Digiorgio Fruit Corp. P.O. Box 127	PL	048	004390	Water Tube	0250	
	PL	042	003470	Water Tube	0250	
	PL	042	003470	Water Tube	0250	
First Baptist Church P.O. Box 1884	HS	000	000364	Water Tube	0150	00050

Name	Code	Diam	Area	Type	Pressure	H.P.
Great Northern Railway Co.	HL	060	000757	Scotch Marine	0015	
Midland Market Rd.	HS	032	000500	Fire Box	0015	
Klamath County	HS	30	200	Fire Box Return Tubular	30	
Annex	CE	-	100	Cast Iron Sectional	30	
	HS	-	430	Water Tube	15	43
	HS	-	430	Water Tube	15	43
Juvenile Home	CE	-	56	Cast Iron Sectional	30	
Health Dept.	CE	-	76	Cast Iron Sectional	30	
Rehab Center	HS	42	200	Fire Box Return Tubular	15	
Klamath Falls Armory c/o Oregon Military Dept. Salem, 97310	HL	53	499	Fire Box Return Tubular	15	50
Klamath Falls Creamery P.O. Box 488	PS	48	500	FTSM	150	50
*Klamath Falls Tallow Co. P.O. Box 1221	PL	66	606	FTSM	130	
Klamath Iron Works	HL	46	500	Fire Box Return Tubular	15	
953 Spring St.	CE	-	60	Cast Iron Sectional	30	10
Klamath Falls Lutheran Church 1175 Crescent	CE	-	80	Cast Iron Sectional	30	8
Klamath Falls Christian Church P.O. Box 5142	HS	16	100	Water Tube	125	
Malin Grain & Seed Box 438 Malin, 97632	PS	46	318	Dry Back Marine	125	
Medo-Bel Dairy Products 1500 Esplanade	PS	16	75	Water Tube	125	8
Merrill Meat Co. Box 400 Merrill, 97633	ME	4	535	D&C	160	20
Merrill Grain & Feed P.O. Drawer C Merrill, 97633	PS	48	350	FT	117	35
Oregon State Hwy Div. State Hwy Bldg. Salem, 97310	HS	22	30	FT	15	3
Odell Lake	HS	31	106	Fire Box Return Tubular	30	
OR. Institute of Technology	PS	16	132	Water Tube	125	20
Pacific NW Bell Telephone Co. 421 Oak Street Portland, 97204	HS	42	300	Fire Box Return Tubular	15	
Pacific Gas	Bonanza	HS	-	Water Tube	160	
Transmission		HS	12	Water Tube	125	15
P.O. Box D	Chemult	HS	36	Dry Back Marine	30	
	Chemult	HS	36	Dry Back Marine	30	

Name	Code	Diam	Area	Type	Pressure	H.P.
Pac. Linen-Mech. Uniform P.O. Box 1166	PL	66	1250	Scotch Marine Dry Back	150	250
Pape Brothers Box 407 Eugene, 97401	HS	54	500	HTG	15	
Pine Grove Pellet Manu. Rt. 2, Box 715	HS	12	141	Water Tube	50	
	PS	12	83	Water Tube	125	15
Pure Pak Sausage Co. P.O. Box 1208	PS	36	110	Water Tube	150	
Sacred Heart Academy 429 N. 8th	HS	48	450	Fire Box Return Tubular	15	45
Sacred Heart Church 815 High Street	CE	-	520	Cast Iron Sectional	15	
	CE	-	36	Cast Iron Sectional	15	
Schulz Tire Service P.O. Box 1467	PS	20	290	Water Tube	125	40
Southern Pac. Trans. Co. c/o R.S. Kilpatrick One Market Plaza, Rm 1100 San Francisco, CA 94105	PL	-	340	VTB	120	34
	PS	4	60	SGEN	300	
T.P. Packing Co. P.O. Box 1810	PS	10	77	Water Tube	160	
	ME	6	77	Water Tube	200	
Witco Chemical 2936 Hilyard	P	78	1250	FTSM	150	250
<u>DESCHUTES COUNTY</u> (Bend except where noted, Bend 97701, Redmond 97756)						
BPOE Lodge #1371 70 Newport St.	HS	40	429	Fire Box Return Tubular	15	
Ralph Bailey Co. P.O. Box 644	ME	4	49	D&C	120	15
Bend City Hall	HS	36	175	Fire Box Return Tubular		
	HS	31	15	Fire Box Return Tubular	15	15
	CE	46	125	Cast Iron Sectional	15	
Bend Redi Mix, Inc. P.O. Box 111	HS	30	41	Water Tube	160	
	HS	24	25	Water Tube	160	
Bend Metro Parks & Rec. Dist. Pacific Park Lane	HS	24	32	FT	160	4
	HS	16	170	FT	140	17
Comm. Presbyterian Church 7 & C St. Redmond	HS	27	54	VFB	30	
Deschutes Co. 1550 Bond St.	HL	33	620	Fire Box Return Tubular	15	
Library	CE	28	27	Cast Iron Sectional	15	25
Shops	HS	552	252	Water Tube	160	

Name	Code	Diam	Area	Type	Pressure	H.P.
Deschutes Ready Mix Sand & Gravel P.O. Box 1008	HS	2	120	FT	15	12
Redmond	HS	-	32	Horizontal Tubular Return	150	
Eberhard Creamery P.O. Box 845 Redmond	PL	60	408	FTSM	125	45
First United Methodist Church 680 Bond St.	HS	27	67	D&C	30	
	HS	27	67	D&C	30	
First Baptist Church P.O. Box 204	CE	50	125	Cast Iron Sectional	30	
Kilgores Dairy 536 S. 6th St. Redmond	PS	48	236	Scotch Marine	125	40
Mainline Corp. 3292 Hwy 97 S. Redmond	PS	42	250	FT	150	50
	DS	36	30	Scotch Marine	150	
Mann Construction P.O. Box 580 Redmond	HS	-	108	Water Tube	125	
Midstate Meat Co. 37 Greenwood St.	PS	24	64	Vertical Tubular	100	
Mission Linen Supply 1200 6th Ave c/o CNA/Loss Control Seattle, WA 98101	PL	72	857	Scotch Marine	175	
North Pac. Products, Inc. W. 14th & Commerce	PL	86	1000	FT	150	
	PL	60	566	FT	100	
OR State Hwy State Hwy Bldg. Salem, 97310	HL	42	893	Fire Box Return Tubular	15	
	HL	54	715	Fire Box Return Tubular	15	
OR Woodwork Ltd.	HS	36	185	Fire Box Return Tubular	15	
Pacific NW Bell Telephone Co. c/o Supt. of Buildings 421 SW Oak St. Portland, 97204	HS	16	42	EBLR	160	
	HS	24	240	HBP	160	
	HS	38	130	FTFB	30	
Pacific Gas Trans. P.O. Box 547 Redmond	HS	36	200	Scotch Marine Dry Back	30	
Redmond Armory 2150 Fairgrounds Rd., NE c/o OR Military Dept. Salem, 97310	HS	29	145	Fire Box	15	
City of Redmond Redmond	CE	44	48	Cast Iron Sectional		
	HE	-	10	BL	125	

Name	Code	Diam	Area	Type	Pressure	H.P.
Redmond Tallow Co.	PL	66	1072	Fire Box Return Tubular	100	
P.O. Box 152	PL	44	700	Fire Box Return Tubular	100	
Redmond						
Redmond Airport	CE	28	30	Cast Iron Sectional	30	
P.O. Box 428						
Redmond						
Redmond Redi Mix	HS	30	16	Coil	150	
P.O. Box 325	HS	30	16	Coil	150	
Redmond						
St. Francis Convent	CE	36	100	Cast Iron Sectional	30	
409 Franklin						
St. Francis School	CE	-	476	Cast Iron Sectional	30	
720 Bond St.	HS	29	175	FT	15	
Sullivan Glove Co.	ME	12	15	Vertical Tubular	15	
P.O. Box 510	CE	30	49	Cast Iron Sectional	30	
Sun River Properties	HS	-	493	Water Tube	150	50
Sunriver, 97701	HS	-	493	Water Tube	150	50
	HS	-	132	Water Tube	125	15
	HS	-	103	Water Tube	125	10
	HS	-	300	Water Tube	125	30
	CE	46	1046	Cast Iron Sectional	15	
Tower Theatre	HS	42	275	Fire Box Return Sectional		
837 Wall St.						
Trinity Episcopal Church	CE	48	117	Cast Iron Sectional	15	
St. Helens & Wall St.						
U.S. Bank of Oregon	CE	-	100	Cast Iron Sectional	100	
P.O. Box 3168						
Portland, 97208						
U.S. National Bank	HS	-	80	Cast Iron	100	
P.O. Box 4410	CE	66	90	Cast Iron Sectional	30	
Portland, 97208						
<u>JACKSON COUNTY</u>						
American Theatres Crop	HL	54	800	Fire Box Return Tubular	15	
544 Golden Gate Ave.	HS	34	130	FB	15	
San Francisco, CA 94102	HS	30	75	Water Tube	15	
American Linen Supply	PL	96	2000	Scotch Marine Dry Back	150	
980 Ellen Ave.						
Medford, 97501						
American Steel & Supply	HS	-	43	Water Tube	125	
P.O. Box 999						
Medford, 97501						
Archdiocese of Portland						
2838 E. Burnside						
Portland, 97214						
St. Mary's H.S.	HS	44	500	Fire Box Return Tubular	15	

Name	Code	Diam	Area	Type	Pressure	H.P.
Archdiocese of Portland, cont.						
School & Convent	HS	36	125	Fire Box Return Tubular	30	
	HS	36	125	Fire Box Return Tubular	30	
	HS	29	150	Fire Box Return Tubular	15	
	HS	48	525	Fire Box Return Tubular	15	
	CE	-	68	Cast Iron Sectional	15	
BPOE No. 944 Ashland, 97520	CE	66	180	Cast Iron Sectional	15	
Harry & David P.O. Box 712 Medford, 97501	PL	-	3000	FT	150	
	PL	72	1503	Scotch Marine	150	
	CE	30	90	Cast Iron Sectional	30	
	PL	72	1503	Scotch Marine	150	
Ken Brown Wholesale Meat P.O. Box 726 Medford, 97501	PS	20	166	Water Tube	150	
Cal Ore Machinery P.O. Box 39 Medford, 97501	HL	52	670	Fire Box Return Tubular	15	
Central Point City Hall Central Point, 97502	HS	26	46	VTLS	30	7
Chemetron Dental Products P.O. Box 429 Ashland, 97520	ME	10	6	Elec	100	
	ME	5	6	Elec	100	
Chevron Asphalt Co. P.O. Box F Concord, CA 94524 (White City Ind. Park)	PS	48	500	FT	200	
Church of Jesus Christ Medford 50 E. North Temple Salt Lake City, UT 84150	HS	20	88	Horizontal Tubular	15	
Crater Osteopathic Hospital 600 S. 2nd St. Central Point, 97501	HS	19	46	Water Tube	160	10
Crater Nat'l Bank 601 Crater Ave. Medford, 97501	HS	32	127	FT	30	28
Farmer Packing Co. 2813 Biddle Rd. Medford, 97501	PS	-	128	Water Tube	125	15
First Methodist Church 607 W. Main Medford, 97501	HS	36	182	Fire Box Return Tubular	15	
First Church of Christian Scientist Windsor & Oak Medford, 97501	CE	48	200	Cast Iron Sectional	30	
First Presbyterian Church 85 S. Holly Medford, 97501	HS	26	200	FT	15	20
	HS	36	164	FT	30	20

Name		Code	Diam	Area	Type	Pressure	H.P.
First Nat'l Bank	Medford	HS	-	30	Water Tube	30	
of Oregon	Ashland	CE	30	45	Cast Iron Sectional	30	
P.O. Box 3131	Central Point	HS	22	40	Fire Box	30	
Portland, 97208	Medford	CE	42	85	Cast Iron Sectional	30	13
	Medford	HS	41	429	Fire Box Return Tubular	15	
First Fed. Savings & Loan		CE	24	40	Cast Iron Sectional	50	
Box 1340							
Medford, 97501							
Jackson County	Phoenix	HS	-	108	Water Tube	30	
Medford, 97501	White City	HL	-	357	Dry Back Marine	30	60
	White City	CE	48	28	HWH	50	
	Ashland Library	HS	30	100	FT	30	10
	Courthouse	HS	44	306	Fire Box	15	
	Courthouse	HS	44	306	Fire Box	15	
	Airport	HS	36	153	Fire Box	15	
	Juvenile Hall	CE	36	60	Cast Iron Sectional	30	
	Health Dept	HS	28	202	Fire Box	30	
	Justice Bldg	HS	9	143	Water Box	125	25
	Justice Bldg	HS	39	13	HB	160	
	Airport	HS	28	10	BL	150	6
	Phoenix Co. Farm	HS	62	500	Scotch Marine Dry Back	30	
	Courthouse	HS	44	390	Fire Box Return Tubular	15	
Jorgenson Dairy Products		PL	66	1000	Dry Back Marine	150	
1300 Court St.		PL	72	5	Scotch Marine Dry Back	150	
Medford, 97501							
Kay Paper Products		HS	27	120	Water Tube	30	
P.O. Box 760							
Medford, 97501							
Kogap Manu. Co.		PL	78	1500	FT	200	
P.O. Box 1608		PL	112	4252	Proc	200	
Medford, 97501		HL	96	2500	FT	15	250
M.C. Liningen & Sons		HS	35	252	Water Tube	45	30
P.O. Box 1145		HL	58	480	Scotch Marine Dry Back	120	
Medford, 97501		HS	40	150	Scotch Marine Dry Back	15	112
Medford Armory		HL	55	755	Firebox Return Tubular	30	
OR State Military Dept.		HS	30	21	HW	125	
2150 Fairgrounds Rd. NE							
Salem, 97310							
*Medford Corp.		PL	48	8160	Water Tube	180	820
P.O. Box 550		PL	48	8160	Water Tube	180	820
Medford, 97501		PL	42	18500	Water Tube	600	
	Rogue River	PL	34	1540	Water Tube	200	350
	White City	PL	60	1000	FT	200	
BPOE No. 1168		CE	20	40	Cast Iron Sectional	160	5
202 N. Central							
Medford, 97501							
Medford Coca Cola Bottling		HS	6	104	HB	125	15
2074 Crater Lake Ave.		HS	-	193	HB	150	40
Medford, 97501		HS	-	285	HB	150	50

Name	Code	Diam	Area	Type	Pressure	H.P.
Medford Mail Tribune 33 N. Fir St. Medford, 97501	HS	-	50	Water Tube	30	10
Medo-Bel Dairy 3550 N. Pacific Hwy Medford, 97501	PS	14	132	Water Tube	125	25
Mid Cave Meat Packing 4775 Table Rock Rd. Medford, 97501	PS	36	128	Water Tube	125	15
Minnesota Mining 8124 Pacific Ave. White City, 97501	PL	-	3291	Water Tube	325	
	PL	30	3616	Water Tube	300	
Morton Milling Co. 500 Ross Anely Dr. Medford, 97501	PS	18	160	Water Tube	125	16
Narad, Inc. 1790 Ave G White City, 97501	PL	42	934	Water Tube	250	2300
Pacific NW Bell Telephone Co. 421 SW Oak St. Portland, 97204	CE	48	112	Cast Iron Sectional	30	
	HS	48	432	Fire Box Return Tubular	15	
	HS	40	429	FB	15	
Reichhold Chemicals, Inc. 1405 Antelope Rd. White City, 97501	PL	304	889	Water Tube	250	
Robue River Packing Corp. P.O. Box 408 Medford, 97501	PL	78	1500	Scotch Marine Dry Back	150	
	PL	78	1500	FTSM	150	
Sabroso Co. P.O. Box 129 Medford, 97501	PL	36	3000		250	800
St. Mark's Episcopal Parrish P.O. Box 566 Medford, 97501	CE	-	86	Cast Iron Sectional	30	
So. Pac. Trans. Co. R.S. Kilpatrick One Market Plaza, Rm 1100 San Francisco, CA 94105	CE	32	32	Cast Iron Sectional	30	
Southern Oregon College Ashland, 97520	HS	90	3571	Fire Box Return Tubular	15	
	HS	-	2500	Fire Box Return Tubular	15	
	HL	-	1429	Fire Box Return Tubular	15	
	HL	84	3307	FB	15	300
	HL	65	2500	Fire Box Return Tubular	15	250
	HL	75	2500	Fire Box Return Tubular	15	250
So. Oregon Sales, Inc. P.O. Box 1266 Medford, 97501	CE	-	45	Cast Iron Sectional	15	

Name	Code	Diam	Area	Type	Pressure	H.P.
So. Oregon Tallow, Inc.	PS	30	510	Water Tube	150	
P.O. Box 244	PL	78	1500	FT	150	
Eagle Point, 97524	PL	90	1211	Scotch Marine	125	
SPRA-Mulch Industries White City 8712 Willow Rd. Redmond, WA 98052	PS	18	225	Water Tube	125	40
3 Jays Dairy 1393 S. Peach St. Medford, 97501	PS	30	106	Vertical Tubular	135	
TruMix Const. Co. P.O. Box 4430 Medford, 97501	HS	12	186	Water Tube	15	25
U.S. Nat'l Bank P.O. Box 4410 Portland, 97208	CE	-	56	Cast Iron Sectional	30	19
	HS	24	41	FB	30	
	HS	35	200	FB	30	
Ashland	HS	40	100	FT	15	
United Grocers, Inc. 2195 Sage Rd. Medford, 97501	CE	-	60	Cast Iron Sectional	15	
Vella Cheese Co., Inc. P.O. Box 3606 Central Point, 97502	PS	48	330	Scotch Marine	125	35
	PS	48	500	Scotch Marine Dry Back	150	100
YMCA 522 West 6th St. Medford, 97501	HS	42	245	FB	15	25
	HS	36	142	FB	30	15
Zion Lutheran Church W. 4th & Oakdale Medford, 97501	CE	-	7	Cast Iron Sectional	50	
<u>DOUGLAS COUNTY</u>						
(Roseburg, Myrtle Creek, Sutherlin, Winston)						
Archdiocese of Portland 2338 E. Burnside Portland, 97218						
St. Joseph's Roseburg	HL	60	1118	Fire Box Tubular Return	15	
	CE	-	25	Cast Iron Sectional	30	
St. Francis Sutherlin	CE	-	115	Cast Iron Sectional	30	
Robert Dollar Co. Glendale, 97442	PL	42	8900	Water Tube	250	
Douglas Co. Road Dept. 2586 Diamond Lake Blvd. Roseburg, 97470	CE	22	43	Cast Iron Sectional	30	
	HS	36	250	Fire Box Tubular Return	30	

Name	Code	Diam	Area	Type	Pressure	H.P.
Douglas County c/o Purchasing Dept. Roseburg, 97470						
Courthouse	HL	66	768	Scotch Marine Dry Back	15	
Justice Bldg	HS	36	200	Elec	125	
	HS	36	200	Elec	125	
	HS	18	36	Elec	15	
Health Center	HS	27	7	EBLR	160	
	HS	32	12	Horizontal Tubular Return	146	
Farmers Co-op	HS	32	129	Fire Box Tubular Return	30	
	PS	30	18	EBLR	125	
Co. Home	HS	-	214	Water Tube	75	
	HS	-	214	Water Tube	75	
BPOE #326 749 SE Jackson Roseburg, 97470	HS	40	280	Fire Box Tubular Return	15	
Empire Pacific Ind. Box 336 Roseburg, 97470	CE	-	31	Cast Iron Sectional	50	
First Methodist Church 1771 SW Harvard Roseburg, 97470	CE	41	65	Cast Iron Sectional	30	
First Christian School 751 SE Main St. Roseburg, 97470	HL	48	500	Fire Box Tubular Return	15	
First Nat'l Bank of Oregon P.O. Box 3131 Portland, 97208	HS	36	309	FT	30	
First Baptist Church 813 SE Lane St. Roseburg, 97470	HS	40	300	Fire Box Tubular Return	30	
Free Methodist Church 2837 W. Harvard St. Roseburg, 97470	CE	-	48	Cast Iron Sectional	50	
Grandview Nursing Home-Roseburg 11669 NE Glisan Portland,, 97220	HS	40	360	Fire Box Tubular Return	30	
*Hanna Nickel Smelting Co. Box 85 Riddle, 97469	HS	24	75	Water Tube	160	
	PL	52	208	Scotch Marine Back	125	20
	PL	52	209	Scotch Maine Back	125	25
IOOF Philaterrian Lodge 713 SE Jackson St. Roseburg, 97470	CE	-	200	Cast Iron Sectional	15	
Masonic Laurel Lodge 13 P.O. Box 958 Roseburg, 97470	CE	48	124	Cast Iron Sectional	15	

Name		Code	Diam	Area	Type	Pressure	H.P.
City of Myrtle Creek Myrtle Creek, 97457	Swimming Pool	HS	-	75	Water Tube	125	
Myrtle Creek Hospital 127 NW Division Myrtle Creek, 97457		ME	8	30	ELBL	100	
		CE	-	1265	Cast Iron Sectional	30	
Oregon National Guard 2150 Fairgrounds Rd., NE Salem, 97310		HS	30	219	FT	36	
Pacific NW Bell Telephone Co. 421 Oak St. Portland, 97204	Roseburg	ME	24	105	EGEN	100	11
City of Roseburg Roseburg, 97476		HS	24	7	EBLR	125	11
		CE	-	90	Cast Iron Sectional	15	9
		HS	8	143	Water Tube	30	
YMCA Stewart Park Roseburg, 97470		HL	60	429	Dry Back Marine	15	
Rose Etta Lodge 1067 NE Stephens Roseburg, 97470		CE	38	62	Cast Iron Sectional	30	
		CE	29	25	Cast Iron Sectional	30	
		HS	-	70	Water Tube	45	
		CE	30	58	Cast Iron Sectional	30	
So. Pacific Trans. Co. R.S. Kilpatrick One Market Plaza, Rm 1100 San Francisco, CA 94105		CE	36	36	Cast Iron Sectional	30	
Varco Corp. P.O. Box 1640 Roseburg, 97470		PS	-	77	FT	175	8
Umpqua Dairy Products 333 SE Sykes Avenue Roseburg, 97470		PL	54	429	Fire Box	125	43
		PS	20	250	Water Tube	150	
Umpqua Savings & Loan Main & Washington Roseburg, 97470		CE	27	30	Cast Iron Sectional	50	11
U.S. Nat'l Bank 321 SW 6th Avenue Portland, 97204	Myrtle Creek Roseburg	CE	30	29	Cast Iron Sectional	30	
		HS	36	100	Fire Box	30	
<u>LAKE COUNTY</u>							
Lakeview							
BPOE Lodge No. 1536 524 Center St. Lakeview, 97630		HS	47	500	Fire Box	15	
First Nat'l Bank of Oregon P.O. Box 831 Lakeview, 97630		CE	48	92	Cast Iron Sectional	15	

Name	Code	Diam	Area	Type	Pressure	H.P.
Masonic Lodge 71 19 South E Street Lakeview, 97630	CE	42	122	Cast Iron Sectional	30	
U.S. Nat'l Bank 321 SW 6th Avenue Lakeview, 97630	CE	36	48	Cast Iron Sectional	30	
Woysen McRanch Box 32 Odel, 97620	PS	48	150	Dry Back Scotch Marine	125	20
<u>LANE COUNTY</u>						
Adams Seed & Feed P.O. Box 206 Springfield, 97477	PL	-	120	FTSM	125	
Agri-Pac, Inc. Eugene	PL	36	898	Water Tube	180	390
P.O. Box 5346	PL	36	898	Water Tube	180	390
Salem, 97304 Junction City	PL	36	1461	Water Tube	250	
	PL	42	1654	Water Tube	160	166
All American Stud Co. Jasper	HL	84	3200	HF	15	
P.O. Box 145	PL	96	3000	FT	150	574
Sweet Home, 97386						
*Bohemia, Inc. Junction City	PL	42	4100	Water Tube	280	410
P.O. Box 1819 *Coburg	PL	36	3425	Water Tube	300	
Eugene, 97440						
Church of Jesus Christ 50 E. North Temple Salt Lake City, UT 84150	HS	26	90	FTFB	30	
Edwards Mint Still 93298 River Rd. Junction City, 97448	PL	57	750	Fire Box	170	75
Falk Farms	PL	78	1500	Scotch Marine Dry Back	150	300
28180 Hwy 36	PL	60	1000	Scotch Marine Dry Back	200	200
Junction City, 97448						
First Nat'l Bank Cottage Grove	HS	29	95	Fire Box	15	
Of Oregon Oakridge	HS	30	65	Fire Box Tubular Return	15	
P.O. Box 3131 Portland, 97209						
IOOF Lodge 68 77500 Hwy 99 Cottage Grove, 97424	HS	34	200	Fire Box Tubular Return	15	
Jackson Farms	PL	60		Scotch Marine Dry Back	150	
28533 Cox Butte Rd. Junction City, 97448						
Jesso, Inc.	PL	83	2143	Fire Box	125	
174 Willamette Dr. Junction City, 97448	PL	73	2280	FT	150	400

Name	Code	Diam	Area	Type	Pressure	H.P.
City of Junction City City Hall Junction City, 97448	Pool HS	-	200	HWH	160	
Junction City Methodist Church 10th & Laurel Junction City, 97448	HS	31	150	Fire Box Tubular Return	30	
Kimwood Corp. P.O. Box 97 Cottage Grove, 97424	CE	-	51	Cast Iron Sectional	15	5
Lane Co. Housing Junction City Authority P.O. Box 907 Eugene, 97440	CE HS	35 36	37 200	Cast Iron Sectional FT	50 30	3 25
Lochmead Dairy 11th & Ivy Sts. Junction City, 97448	PS	20	172	Water Tube	125	
Our Lady of Perpetual Help 2838 E. Burnside Portland, 97207	Cottage Grove HS	36	150	Fire Box Tubular Return	30	
Pacific NW Bell Telephone Co. 421 SW Oak Portland, 97204	Cottage Grove HS	42	252	Fire Box	30	
Paeschke Farms, Inc. 1470 W. 18th Junction City, 97448	PL PL	84 96	2143 2500	Fire Box FT	125 150	500
Panis Sunnyside Greenhouses 1704 W. Main Cottage Grove, 97424	HL HS	52 42	617 257	Fire Box FT	30 30	70
*Pope & Talbot P.O. Box 426 Oakridge, 97463	PL PL PL	48 36 36	8430 5225 5225	Water Tube Water Tube Water Tube	225 225 225	843 523 523
U.S. Nat'l Bank 321 SW 6th Portland, 97204	Cottage Grove CE Junction City CE	24 30	22 50	Cast Iron Sectional Cast Iron Sectional	30 30	
*Willamette Poultry Co. P.O. Box 246 Cresswell, 97426	PL PS PS	60 8 12	1000 104 270	FT D&C DCBL	150 160 200	200 50 50
Archdiocese of O'Hara School Portland 2838 E. Burnside Portland, 97214	HE HL CE	30 56 50	11 628 170	CWHR Fire Box Tubular Return Cast Iron Sectional	30 15 15	5
BPOE Lodge No. 357 2727 Centennial Blvd. Eugene, 97401	CE CE	39 62	88 140	Cast Iron Sectional Cast Iron Sectional	50 15	

Name	Code	Diam	Area	Type	Pressure	H.P.
*J.H. Baxter Co.	CE	41	75	Cast Iron Sectional	30	
P.O. Box 10797	PL	102	2000	Scotch Marine	150	200
Eugene, 97440	PL	64	499	FT	125	
	PL	84	2003	Scotch Dry Back	150	200
Bethesda Evangelical Lutheran	CE	36	113	Cast Iron Sectional	30	
445 Royal Ave.						
Eugene, 97402						
Bohemia, Inc.	PL	36	6520	Water Tube	250	652
P.O. Box 1819 Saginaw Sawmill	PL	36	3455	Water Tube	260	345
Eugene, 97440	PL	42	7602	Water Tube	300	800
Cascade Pole Co.	PL	84	1500	Horizontal Tube	150	150
P.O. Box 2667						
Eugene, 97402						
Cascade Fiber Co.	PL	96	1500	FT	267	300
2280 Oakmount Way	PL	66	1000	Scotch Marine	250	125
Eugene, 97401						
*Cascade Handle Co.	PL	66	1250	Horizontal Tube	130	125
P.O. Box 364						
Eugene, 97401						
*Cascadian Co.	HL	52	680	Fire Box	15	
P.O. Box 12						
Eugene, 97401						
Cascade Manor	HL	-	715	Scotch Marine Dry Back	60	
65 W. 30th Ave.	HL	-	715	Scotch Marine Dry Back	60	
Eugene, 97405						
Cascade Resins, Inc.	PS	-	281	Water Tube	150	
P.O. Box 1989						
Eugene, 97401						
Central Lutheran Church	CE	36	112	Cast Iron Sectional	30	
1857 Potter	HS	31	120	Fire Box Tubular Return	30	
Eugene, 97403	CE	34	70	Cast Iron Sectional	30	
Central Presbyterian Church	HS	42	252	Scotch Marine	15	
1474 Ferry St.	HS	42	252	Scotch Marine	15	
Eugene, 97401						
Champion Buildings Products	PL	48	6500	Water Tube	250	650
P.O. Box 672						
Eugene, 97401						
Chi Omega Fraternity	CE	-	140	Cast Iron Sectional	30	
1461 Alder						
Eugene, 97401						
Church of Jesus Christ	HS	30	200	Fire Box Tubular Return	30	
Op. & Maintenance						
50 E. North Temple						
Salt Lake City, UT 84150						

Name	Code	Diam	Area	Type	Pressure	H.P.
Coca Cola Bottling Co. 1565 Franklin Blvd. Eugene, 97403	HS	-	220	Water Tube	30	50
Community Center WOW Hall 8th & Lincoln Eugene, 97401	HS	25	67	Fire Box Tubular Return	15	
Cox Dental Lab. 1241 Oak St. Eugene, 97401	CE	-	50	Cast Iron Sectional	30	50
Delta Delta Delta 1987 University Ave. Eugene, 97403	CE	48	150	Cast Iron Sectional	15	
	CE	25	75	Cast Iron Sectional	15	
Delta Gamma Sorority 1584 Alder Eugene, 97401	HS	36	100	Dry Back Marine		
Delta Tau Delta 1886 University Eugene, 97403	CE	-	23	Cast Iron Sectional	100	
	CE	-	100	Cast Iron Sectional	15	
Dominion Manufacturing Co. 1300 Bechel Drive, Suite B Eugene, 97402	HS	53	700	Fire Box Tubular Return	15	
Echo Spring Dairy 1750 8th Ave. W Eugene, 97402	PL	50	3000	Dry Back Marine	100	30
	PS	48	250	FT	150	
Emerald Baptist Church 19th & Patterson Eugene, 97405	HS	18	260	Water Tube	30	
Emerald Cold Storage 865 Grant St. Eugene, 97402	PS	48	250	FT	150	
Eugene Concrete Pipe & Products Co. Box 947 Eugene, 97401	PL	66	437	Scotch Marine	125	40
	PS	48	206	FTSM	125	25
Eugene Country Club 255 Country Club Rd. Eugene, 97401	CE	36	150	Cast Iron Sectional	50	20
	HE		150	Horizontal Back	150	10
Eugene Hospital, Inc. 1162 Williamette Eugene, 97401	ME	6	20	SGEN	100	2
	ME	12	20	SGEN	100	2
Eugene Sand & Gravel P.O. Box 1067 Eugene, 97401	HS	26	5833	Water Tube	15	
	HS	36	80	FT	15	

Name	Code	Diam	Area	Type	Pressure	H.P.
*Eugene & Water Electric Board	PL	41	166	Water Tube	300	920
500 4th Ave. E.	PL	47	285	Water Tube	250	
Eugene, 97401	PL	42	26335	Water Tube	707	2633
Eugene Scottish Rite Assn.	HS	40	235	Fire Box	15	
P.O. Box 2245						
Eugene, 97402						
Norman Evonuk Mint Still	PL	60	893	Fire Box	125	90
34377 Seary Loop Rd.						
Eugene, 97405						
First Church of Christian Scientist	HS	36	154	Fire Box	15	
1390 Pearl St.						
Eugene, 97401						
First Church of the Nazarene	HS	24	41	Water Tube	125	10
727 W. Broadway						
Eugene, 97402						
First Nat'l Bank of Oregon	CE	24	270	Cast Iron Sectional	50	
P.O. Box 3131	CE	48	48	Cast Iron Sectional	30	
Portland, 97208	HS	22	79	Water Tube	30	
	CE	34	75	Cast Iron Sectional	30	
Fraternal Order of Eagles	HS	44	266	Fire Box Tubular Return	15	
519 Willamette						
Eugene, 97401						
Gheen Irrigation Works	PL	65	625	Scotch Marine Dry Back	125	75
500 Willagilliespie Rd.						
Eugene, 97401						
Grace Lutheran Church	HS	42	300	Fire Box	30	
710 E. 17th Ave.						
Eugene, 97401						
Green Valley Care Center	HS	24	25	Horizontal Back	160	3
1735 Adkins St.	HS	24	25	Horizontal Back	160	3
Eugene, 97401						
Griffith Rubber Mills	PL	50	250	FT	150	
575 Wilson St.						
Eugene, 97402						
Harbert & Downing Farms	PL	78	1250	Scotch Marine Dry Back	150	125
Rt. 2, Box 391						
Eugene, 97401	PL	54	419	FT	125	200
IOOF Temple	HS	44	177	Fire Box	30	
1225 Charnelton						
Eugene, 97401						
Ivorene Care Center	HS	16	104	Water Tube	125	20
687 Cheshire St.	HS	15	7	Cook	15	2
Eugene, 97401	HS	24	97	HWH	160	

Name	Code	Diam	Area	Type	Pressure	H.P.
Kappa Kappa Gamma Sorority 821 E. 15th St. Eugene, 97401	CE	32	59	Cast Iron Sectional	30	
Kappa Alpha Theta 1840 Onyx Eugene, 97403	CE	40	200	Cast Iron Sectional	30	
Lane Plywood Inc. 65 N. Bertelsen Rd. Eugene, 97402	PL	42	2250	Water Tube	200	225
	PL	42	2250	Water Tube	200	225
	PL	30	4150	Water Tube	325	415
Mansell Recapping 1875 W. 7th St. Eugene, 97402	PS	-	67	Water Tube	125	10
E.A. Mock & Son 1711 Willamette Eugene, 97401	HS	27	155	FT	15	
Monsanto Co. 855 Seneca Eugene, 97402	ME	16	40	ESGN	150	
	ME	12	15	ESGN	100	
	PL	-	3455	Water Tube	270	345
	PS	20	48	ESGN	600	2
Morse Brothers, Inc. P.O. Box 7 Lebanon, 97355	HS	36	250	BL	15	40
NW Natural Gas 123 NW Flanders St. Portland, 97209	HS	-	1332	Water Tube	125	
Northwest Christian College 328 E. 11th St. Eugene,	HS	32	65	FBFT	15	10
	CE	26	24	Cast Iron Sectional	30	
	CE	22	24	Cast Iron Sectional	30	
	CE	26	55	Cast Iron Sectional	30	
Our Redeemer Lutheran Church 255 Maxwell Rd. Eugene, 97402	CE	42	101	Cast Iron Sectional	30	
Pacific NW Bell Tel. Co. 421 SW Oak Portland, 97204	CE	32	65	Cast Iron Sectional	30	
Pacific Resin & Chemicals 188 Irving Eugene, 97402	PL	-	4005	Water Tube	260	400
Pape Brothers P.O. Box 407 Eugene, 97401	PS	7	104	Water Tube	160	55
Phi Gamma Delta 791 E. 15th St. Eugene, 97401	HS	30	146	Fire Box Tubular Return	30	
	CE	24	30	Cast Iron Sectional	100	3
Phi Kappa Alpha 818 E. 15th Eugene, 97401	HS	29	80	Fire Box Tubular Return	15	

Name	Code	Diam	Area	Type	Pressure	H.P.
Pi Beta Phi Sorority	CE	26	26	Cast Iron Sectional	30	
1518 Kincaid	CE	34	85	Cast Iron Sectional	40	
Eugene, 97401						
Pierce Corp.	PS	12	68	Water Tube	125	14
P.O. Box 528						
Eugene, 97401						
Pleasant Valley Nursing Home	CE	-	8	Cast Iron Sectional	30	
395 W. 29th Ave.						
Eugene, 97405						
Rexius Forest By-Products	CE	22	50	Cast Iron Sectional	30	8
750 Chambers St.						
Eugene, 97402						
River Road Baptist Church	HS	36	125	Fire Box Tubular Return	30	
1105 River Road						
Eugene, 97402						
River Road Park & Rec. District	HS	24	130	Water Tube	15	
1400 Lake Drive						
Eugene, 97402						
Santa Clara Assembly of God	CE	-	58	Cast Iron Seccional	30	
815 Irving						
Eugene, 97402						
Seventh Day Adventist Church	HS	36	201	Fire Box Tubular Return	30	
1275 Polk						
Eugene, 97402						
Sigma Kappa Sorority	HS	30	130	Fire Box Tubular Return	30	
851 E. 15th St.						
Eugene, 97401						
Sigma Nu Fraternity	HS	30	88	Fire Box Tubular Return	30	
763 E. 11th St.						
Eugene, 97401						
Sigma Phi Epsilon Fraternity	HS	36	150	Scotch Marine Dry Back	30	
1000 Alder St.						
Eugene, 97401						
Sigma Chi	CE	34	120	Cast Iron Sectional	30	
1440 19th Ave. E						
Eugene, 97403						
Southern Pacific Transport Co.	CE	36	75	Cast Iron Sectional	30	
One Market Plaza, Rm 1100	PS	48	171	SGEN	300	
c/o R.S. Kilpatrick	PS	48	171	SGEN	300	100
San Francisco, CA 94105						
States Veneer, Inc.	PS	9	198	Water Tube	200	
P.O. Box 7037	PL	60	1000	FT	300	
Eugene, 97402	PS	30	270	Water Tube	300	
Theta Chi Fraternity	CE	49	105	Cast Iron Sectional	30	
1125 E. 14th St.						
Eugene, 97403						

Name	Code	Diam	Area	Type	Pressure	H.P.
Treplex, Inc. P.O. Box 2663 Eugene, 97401	PL	36	7500	Water Tube	250	750
Tri Valley Meat Co. 90579 Hwy 99N Eugene, 97402	HS	4	77	Water Tube	125	15
Trinity Methodist Church 440 Maxwell Rd. Eugene, 97402	CE	37	100	Cast Iron Sectional	30	
	CE	34	150	Cast Iron Sectional	30	
United Lutheran Church 2230 Washington St. Eugene, 97405	HS	26	70	Fire Box Tubular Return	30	
Universal Equip. Co. 4190 Franklin Blvd. Eugene, 97403	HS	24	195	Water Tube	125	
	CE	34	40	Cast Iron Sectional	30	4
U.S. Nat'l Bank 321 SW 6th Ave. Portland, 97204	HS	24	30	Water Tube	30	
	CE	24	1200	Cast Iron Sectional	30	
	HS	23	89	Water Tube	30	
	CE	38	40	Cast Iron Sectional	30	
George Watson Greenhouse 2420 Bertelson Rd., S Eugene, 97405	HS	48	186	Dry Back Marine	15	
Wesley Methodist Church 1385 Oakway Rd. Eugene, 97401	HS	-	240	Water Tube	45	
	HS	-	40	Water Tube	45	
Westminister Presbyterian Church 777 Coburg Rd. Eugene, 97401	HS	38	150	Fire Box	30	15
	HS	38	186	Fire Box	30	18
Wildish Sand & Gravel Co. P.O. Box 7428 Eugene, 97401	HS	42	224	FT	30	25
	CE	32	55	Cast Iron Sectional	30	
Willamette Beverages 3030 Judkins Rd. Eugene, 97403	HS	24	440	Water Tube	125	50
Williams Bakery 1760 E. 13th St. Eugene, 97401	HL	60	757	Scotch Marine	15	
	HS	-	31	Water Tube	130	
*Wyatt's 390 W. 11th St. Eugene, 97401	PL	-	65	Scotch Marine Dry Back	125	60
	PS	6	87	Water Tube	125	
*YMCA 2055 Patterson Eugene, 97405	HS	28	200	EBLR	125	
	HS	39	900	EBLR	125	
	HE	15	18	EBLR	15	

Name	Code	Diam	Area	Type	Pressure	H.P.
Archdiocese of Springfield Portland St. Alice School 2838 E. Burnside Portland, 97214	HS	36	181	Fire Box Tubular Return	30	
Bordon Chemical Co.	PL	36	4306	Water Tube	250	
470 S. 2nd St.	HS	36	150	Scotch Marine Dry Back	30	
Springfield, 97477	PS	12	47	Water Tube	125	
	PS	36	440	Water Tube	260	
	PS	96	2526	Scotch Marine Dry Back	150	253
*Chembond Corp.	PL	72	2109	BLR	200	210
P.O. Box 270	PL	38	1285	BLR	75	128
Springfield, 97477	PL	66	1500	FT	150	150
Chel Francisco	PS	24	345	Water Tube	125	69
P.O. Box 1187	PS	-	793	Water Tube	125	150
Springfield, 97477	HS	8	331	Water Tube	100	
	HS	28	245	Water Tube	160	57
*Clear Fir Products	PL	72	1500	Horizontal Tubular Return	150	150
P.O. Box 38	PL	72	15	Horizontal Tubular Return	150	150
Springfield, 97477						
Ebbert Memorial Methodist Church	HS	36	225	Fire Box Tubular Return	15	
537 C St.						
Springfield, 97477						
Edmonds Building	HS	28	125	Fire Box Tubular Return	30	
1235 Willamette						
Eugene, 97401						
Equitable Savings & Loan	HS	-	8	Water Tube	125	1
707 Main St.						
Springfield, 97477						
First Nat'l Bank of Oregon	CE	37	68	Cast Iron Sectional	30	
P.O. Box 3131						
Portland, 97208						
Hamilton Construction	HS	-	50	Cast Iron Sectional	15	10
P.O. Box 659						
Springfield, 97477						
Huntington Shingle Co.	HL	56	625	Scotch Marine Dry Back	15	75
P.O. Box 109						
Springfield, 97477						
Kingsford Co.	PS	28	20	FL	129	
3315 Mohawk Rd.	PS	48	500	Scotch Marine Dry Back	150	
Springfield, 97477						
Natron Division	PS	9	123	Water Tube	200	
Brand S Corp.						
Box 2						
Springfield, 97477						

Name	Code	Diam	Area	Type	Pressure	H.P.
Oregon Aqua-Foods, Inc.	CE	20	30	Cast Iron Sectional	160	5
38700 Marcola Rd.	CE	20	30	Cast Iron Sectional	160	5
Springfield, 97477						
Pacific First Fed. Savings & Loan	HS	8	20	Water Tube	150	
640 No. A St.	HS	8	20	Water Tube	150	
Springfield, 97477						
City of Springfield	CE	34	96	Cast Iron Sectional	15	
4th & No. A Sts.	HS	29	72	EBLR	30	
Springfield, 97477	HS	29	72	EBLR	30	
U.S. Nat'l Bank	CE	-	6	Cast Iron Sectional	30	4
321 SW 6th Ave.						
Portland, 97204						
Willamalane Park District	HS	36	215	HWHB	30	
8th & A Sts.	HL	54	800	Fire Box	15	
Springfield, 97477						
Willamette Industries	HE	28	32	Coil	160	
419 S. 28th St.	HL	90	2857	FTFB	15	
Springfield, 97477	PL	60	625	FT	150	63
	HS	-	50	Water Tube	150	5
<u>JOSEPHINE COUNTY</u>						
Grants Pass except where noted						
Zip Code 97526						
BPOE Lodge No. 1584	HS	36	238	Fire Box	30	
Bethany Presbyterian Church	HS	27	200	FT	30	20
748 NW 5th	HS	26	135	HBR	15	13
Courier Publishing Co.	HS	36	350	Fire Box Tubular Return		
First Nat'l Bank of Oregon	HS	38	187	Fire Box	30	
P.O. Box 3131						
Portland, 97208						
Four Ply, Inc.	PS	10	270	Water Tube	200	50
P.O. Box 890	PS	11	270	Water Tube	300	
Fry Mint Farmers, Inc.	PL	76	1250	Scotch Dry Back	125	125
606 High St., SE						
Salem, 97301						
Grants Pass Moulding Co.	HL	76	956	FT	15	
P.O. Box 447						
Josephine County	HS	17	24	EBLR	15	
	HS	17	24	EBLR	15	
	CE	-	60	Cast Iron	50	
	HS	24	90	EBLR	150	9
	HE	30	318	Water Tube	125	50

Name	Code	Diam	Area	Type	Pressure	H.P.
Masonic Temple 84 320 NW E St.	CE	35	60	Cast Iron Sectional	30	
101 Corporation	CE	35	50	Cast Iron Sectional	30	
111 SE 6th	CE	24	50	Cast Iron Sectional	50	
Oregon State Armory 2150 Fairgrounds Rd. Military Dept. Salem, 97310	HS	42	239	FT	30	30
Pacific NW Bell Tel Co. 421 SW Oak St. Portland, 97204	HS	30	175	Fire Box	15	
Rogue Gold Dairy, Inc. 234 SW 5th	PS	34	98	FTSM	125	15
Seventh Day Adventist Church 11291 Pierce St. Riverside, CA 92505	CE	-	60	Cast Iron Sectional	50	
So. Oregon Hospital 1505 NW Washington Blvd.	HS	28	12	HW	150	
Spalding & Son P.O. Box 438	HS	76	1800	Fire Box	15	
Tim-Ply Co. 125 Mill St.	PL	-	4479	Water Tube	385	448
U.S. Nat'l Bank 321 SW 6th Ave. Portland, 97204	HS	36	153	FT	15	
Valley of the Rogue Dairy P.O. Box 1327	PS	44	144	Dry Back Marine	125	20
Valley Meat Co. 825 Union Ave.	HS	18	67	Water Tube	125	15
	CE	21	35	Cast Iron Sectional	7	3

* Individuals also on DEQ list

Appendix C

MARKET SURVEY INTERVIEW QUESTIONNAIRE

WOOD ENERGY MARKET SURVEY FOR MODOC LUMBER CO.
& U.S. DEPARTMENT OF ENERGY

October, 1981

PURPOSE OF SURVEY

In August, 1980 Modoc Lumber Co. of Klamath Falls received a U.S. Department of Energy grant to study the feasibility of densifying wood waste into pellets for use as an alternate fuel in boilers. As part of this study, Eliot Allen & Associates, Inc., of Salem, Oregon, has been retained to conduct a market survey of potential wood fuel users.

The Survey is voluntary and results will be used for statistical purposes only.

INTRODUCTION TO WOOD PELLETS

The wood products industry has long relied on both wood and bark residues to help supply energy needs. Recent interest has focused on the densified form of these residues. Such densified products include the old familiar fuel logs, stoker fuel briquettes, and pelletized residues. These densified forms of renewable energy are now economically viable for industrial and commercial heating applications.

Densified wood residues include sawdust, shavings and hogged fuel (bulk wood and bark) compressed together without the aid of a binder for use as fuel. There are three types of wood briquettes; they are fuel logs, stoker fuel, and fuel pellets.

Pellet densification is accomplished by heating shavings to a range of 100-200°F and mechanically forcing the feedstock into a die, which results in a fully compacted pellet moulded to the shape of the die. Finished pellets have a moisture content of approximately 5-10% and combustion heat of 16 million Btu's per ton.

Use of pellets as a replacement for coal is well established, with suspension or spreader stoker firing systems requiring virtually no modification for pellet use. Wood burning systems are also readily available. These types of direct combustion can yield steam, process heat or even electricity when coupled with a turbine-generator.

WOOD ENERGY PRODUCTS

SURVEY

COMPANY NAME _____

SIC# _____

ADDRESS _____

INTERVIEWEE _____

POSITION _____

TELEPHONE _____

INTERVIEWER _____ DATE _____

1) DESCRIPTION OF PLANT(S):

Plant Number	Location	Approximate Number of Employees
1		
2		
3		
4		
5		

Estimated Remaining Useful Life (in years) of: (Circle Response)	
Space/Process Heating Equipment	Total Plant with Structures
< 2 2-5 6-10 11-15 16-20 > 20	< 2 2-5 6-10 11-15 16-20 > 20
< 2 2-5 6-10 11-15 16-20 > 20	< 2 2-5 6-10 11-15 16-20 > 20
< 2 2-5 6-10 11-15 16-20 > 20	< 2 2-5 6-10 11-15 16-20 > 20
< 2 2-5 6-10 11-15 16-20 > 20	< 2 2-5 6-10 11-15 16-20 > 20
< 2 2-5 6-10 11-15 16-20 > 20	< 2 2-5 6-10 11-15 16-20 > 20

2) Before we contacted you, was your firm familiar with the use of wood pellets for supplying space, H₂O, and process heat? Check response.

- Unfamiliar..... ☐
- Slightly familiar with wood pellets..... ☐
- Familiar, but not enough to support a decision (pro or con) regarding the use of wood pellet fuel..... ☐
- Sufficient knowledge to make a decision (pro or con)..... ☐

3) Has your company made an engineering feasibility study on the application of wood pellet boiler fuel?

Yes ☐ No ☐

If so, what did the study show?

4) Do you feel that your company would do an engineering feasibility study on the use of wood pellets if a firm source was potentially available?

Yes ☐ No ☐

- 5) Are you aware of any companies which are currently using wood pellets for space or process heat?

Yes ☐ No ☐

If yes, has this demonstrated use been a success in your opinion?

Yes ☐ No ☐ Unsure ☐

Has the use of wood pellets been demonstrated in processes which are similar to those used in your plant?

Yes ☐ Not aware of any ☐

- 6) Suppose wood pellets were available at your present plant site(s) in sufficient quantity to meet your needs for space, water, and process heat. If they were sufficiently cheap, would you seriously consider using this source of heat - either through a retrofit of the existing plant

Yes ☐ No ☐

or in a new plant?

Yes ☐ No ☐

(Note: "Seriously consider" does not necessarily imply a final decision favorable to wood pellets)

- 7) If No, would you seriously consider using this source of heat if its use had been demonstrated commercially by other companies?

- in your own line of business Yes ☐ No ☐

- in other lines of business Yes ☐ No ☐

- 8) If your firm were considering using wood pellets, how long would it take to make this decision, given the managerial structure of your firm? Circle response.

Time (in years) < 1/2 1 2 3 4 5 > 5

- 9) If your firm were to utilize wood pellet boiler fuel, a front end capital investment would be required to retrofit the existing boiler(s) for wood pellet combustion. Assuming

the payback period was acceptable,

If the retrofit investment was:

Is it likely that your company would choose to invest in the opportunity?

- a) < \$10,000
- b) \$10- 25,000
- c) \$25- 50,000
- d) \$50-100,000
- e) >\$100,000

Yes ☐	No ☐
Yes ☐	No ☐
Yes ☐	No ☐
Yes ☐	No ☐
Yes ☐	No ☐

- 10) If you answered "No" to any of these cases, suppose the federal or state government offered to cover a percentage of your retrofit investment through grants, loans or tax credits. Is it likely that this would make your firm choose to invest in this opportunity?

Case a)	Yes ☐	No ☐
b)	Yes ☐	No ☐
c)	Yes ☐	No ☐
d)	Yes ☐	No ☐
e)	Yes ☐	No ☐

- 11) The difference in price for energy equivalents of wood pellets and your current boiler fuel amounts to potential savings. These savings, in turn, are recouped against your conversion investment, resulting in investment payback or capital recovery period. What is the maximum payback period, in years, your firm would accept? (Please circle)

.5 1 1.5 2 2.5 3 3.5 4 4.5 5 6 7 8 9 10

Appendix D

SUPPLIERS OF DBF EQUIPMENT

This listing of manufacturers and equipment does not constitute an endorsement or recommendation of and kind; nor it is intended to necessarily include all manufacturers of such equipment.

<u>Firm</u>	<u>Products</u>
Aeroglide Corporation 7100 Hillsborough Rd. Raleigh, NC 27602 919/851-2000	Dryers.
Agnew Environmental Products Company P.O. Box 1168 Grants Pass, OR 97526 503/479-3396	Briquettor for densification of dry fibrous waste into fuel or fireplace logs.
Air-O-Flex Equipment Co. 3030 E. Hennepin Ave. Minneapolis, MN 55413 612/331-4925	Truck dumps.
Air-Tech Industries, Inc. 85 Madison Circle Drive E. Rutherford, NJ 07073 201/460-9730	Inflatable storage equipment-air bags.
American Sheet Metal, Inc. P.O. Box 9 Tualatin, OR 97062 503/638-9611	Wood wastes storage and conveying systems.
Archer Blower, Inc. 6200 SW Virginia Avenue Portland, OR 97201 503/246-7755	Wood wastes storage and conveying systems.
Atlas Systems Corporation P.O. Box 11496 Spokane, WA 99211 509/535-7775	Shredded wood residue storage silos, automatic discharge system.

Firm

Bahco Systems, Inc.
P.O. Box 48116
Atlanta, GA 30362
404/427-9051

Bigelow Machinery, Inc.
407 N. Columbia Blvd.
Portland, OR 97217
503/289-7319

Black Clawson, Inc.
P.O. Box 1028
Everett, WA 98206
206/258-3555

Bocats, Inc.
P.O. Box 1021
Garden City, KS 67846
316/275-7167

California Pellet Mill Co.
1114 E. Wabash Avenue
Crawfordville, IN 47933
317/362-2600

CEA, Carter Day Company
500 73rd Ave., NE
Minneapolis, MN 55430
612/571-1000

Clark's Sheet Metal, Inc.
P.O. Box 2428
Eugene, OR 97402
503/343-3395

Consolidated Baling
Machine Company
155D 7th Street
Brooklyn, NY 11215
212/625-0929

Convey International
P.O. Box 1399
Roseburg, OR 97470
503/672-5506

Cornell Manufacturing, Inc.
Laceyville, PA 18623
717/869-1227

Product

Bark classifiers and driers,
dust collectors.

Bark and wood hogs.

Fuel preparation components
and systems.

Live bottom and chip trailers.

Pelletizer equipment.

Bulk storage, wood residue
handling equipment.

Storage handling systems for
wood chips and dust.

Baling presses for wood
residue.

Fuel preparation components
and systems.

Wood residue handling equip-
ment, wood splitters,
hydraulic slab saws.

FirmProduct

Diversified Fuel of
America, Inc.
P.O. Box 10247
Eugene, OR 97401
503/484-0371

Equipment for making pellet-
ized wood fuel.

Ferro-Tech
467 Eureka Road
Wyandotte, MI 48192
313/282-7300

Briquetting equipment.

FMC Corporation
MHS Division
3400 Walnut Street
Colmar, PA 18915
215/822-0581

Fuel handling systems.

Goodman Equipment Corporation
4834 South Halsted Street
Chicago, IL 60609
312/927-7420

Double anvil wood hog and
chipmills.

Gruendler Crusher and
Pulverizer Company
2915 N. Market Street
St. Louis, MO 63106
314/531-1220

Grinders, crushers, and
shredders.

Guaranty Performance Co., Inc.
P.O. Box 748
Independence, KS 67301
316/331-0027

Rotary driers, related fuel
handling equipment.

Harvey Engineering and Manu-
facturing Corporation
Rt. 2, Box 478
Hot Springs, AR 71901
501/262-1010

Fuel storage, handling, and
preparation systems.

Harris Press Company
Subsidiary of American Hoist
Cordele, GA 31015
912/273-5646

High pressure baling press
for wood and bark residue.

Heil Company
3000 W. Montana
Milwaukee, WI 53201
414/647-3101

Dehydration equipment for
predrying sludges of bark-
wood-sawdust, etc.

FirmProduct

Hobbs Adams Engineering
Company, Inc.
1100 Holland Road
Suffolk, VA 23434
804/539-0232

Hogs and related equipment.

S.W. Hooper Corporation
2111 Powers Ferry Road
Atlanta, GA 30339
404/955-4136

Unhogged fuel reclamation
systems.

Industrial Burner
24 W. Third Avenue
Spokane, WA 99204
509/747-7965

Fuel preparation, handling
systems.

Jacksonville Blow Pipe Co.
P.O. Box 3687
Jacksonville, FL 32206
904/355-5671

Wood/bark hogs, pneumatic
blower systems.

Jeffrey Manufacturing Division
Dresser Industries, Inc.
500 East Morehead St., Room 221
Charlotte, NC 28202
704/375-8600

Fuel handling, processing
equipment and hogs.

Kinergy Corporation
4827 Jennings Lane
Louisville, KY 40218
502/964-5901

Vibrating screens, feeders,
and conveyors; dust screens.

Laidig, Inc.
1320 S. Merrifield Ave.
Mishawaka, IN 4654
219/256-0204

Wood refuse handling systems.

Lamb, Inc.
419 First Southern Tower
851 Beltline Highway
Mobile, AL 36606
205/479-7401

Hogs and related equipment.

Mardee, Inc.
3129 E. Washington
Madison, WI 53704
608/244-3331

Fuel preparation, handling
storage systems.

Firm

Maren Engineering Corp.
111 W. Taft Drive
South Holland, IL 60473
312/333-6250

McBurner Corporation
P.O. Box 26210
Birmingham, AL 35226
205/942-3321

M-E-C Company
P.O. Box 330
Neodesha, KS 66757
316/325-2673

Mill Supply Company
P.O. Box 3748
Missoula, MT 59801
406/543-7197

Miller Hofftt, Inc.
P.O. Box 8560
Richmond, VA 23226
703/288-1937

Modomekan, Inc.
Suite 300
2175 Parklake Dr., NE
Atlanta, GA 30345
404/934-3151

Morbark Industries, Inc.
P.O. Box 1000
Winn, MI 48896
517/866-2381

Papakube Corporation
931 East Harbor Drive
San Diego, CA 92101
714/231-1490

Peabody Gordon-Piatt, Inc.
P.O. Box 650
Winfield, KS 67156
316/221-4770

Peerless Royal Division
Royal Industries, Inc.
P.O. Box 760
Paragould, AR 72450
501/236-7753

Product

Baline press for wood shavings, sawdust.

Fuel preparation, handling systems.

Rotary drum dryers, flash tube dryers, wood residue fuel preparation systems.

Wood residue feeding systems.

Storage and feeding equipment for wood residues.

Wood residue storage, handling systems.

Fuel harvesting machinery, chip classification hardware.

Pelletizer equipment.

Fuel metering bins.

Fuel storage silos, live bottom trailers, and truck dumps.

Firm

Protran, Inc.
P.O. Box 10764
Raleigh, NC 27605
919/781-4148

Rader Pneumatics, Inc.
P.O. Box 20128
Portland, OR 97330
503/255-5330

Rexnord, Inc.
Vibrating Equipment Div.
3400 Fern Valley Rd.
Louisville, KY 40213
502/969-3171

Salem Hammermill Company
2601 Industrial Drive
Salem, VA 24153
703/389-8696

Schutte Pulverizer Co., Inc.
61 Depot Street
Buffalo, NY 14240
716/855-1555

Sprout-Waldron
Division of Koppers Co., Inc.
130 Logan Street
Muncy, PA 17756
717/546-8211

Stearns-Roger, Inc.
P.O. Box 5888
Denver, CO 80217
303/758-1122

Steelcraft Corporation
P.O. Box 12408
Memphis, TN 38112
901/452-5200

Thermal Processes, Inc.
507 Willow Springs Rd.
La Grange, IL 60525
312/354-8771

Taiga International, Inc.
11120 Roselle St., Suite J
San Diego, CA 92121
714/452-8630

Product

Briquetting equipment.

Pneumatic handling and conveying equipment and truck dumps.

Vibrating conveyors to boiler feed.

Wood/bark grinders, air conveyors, screw elevating equipment, dumps and hoists.

Industrial hammermills.

Wood residue storage structures, equipment for pelletizing, size classification, and materials handling.

Rotary fuel dryers for hogged wood fuel.

High/low pressure pneumatic material conveying systems, filter collectors, storage bins.

Fluidized bed burners.

Pelletizing equipment.

Firm

Union Heating, Inc.
7833 196 Southwest
Edmonds, WA 98020
206/775-4588

Weaver Star Silo, Inc.
Route 4
Myerstown, PA 17067
717/866-5708

Wellons, Inc.
P.O. Box 381
Sherwood, OR 97140
503/625-6131

Williams Patent Crusher Co.
2701 N. Broadway
St. Louis, MO 63102
314/621-3348

Product

Automatic fuel feeders for
Dutch oven boilers, waste
hydrogen burners.

Silos.

Wood fuel storage bins,
conveyors.

Size reduction and fuel drying
equipment.

Appendix E

CITY OF KLAMATH FALLS SITE PLAN REVIEW DECISION
AND FINDINGS FOR THE PILOT PLANT

CITY OF KLAMATH FALLS, OREGON

P. O. BOX 237
ZIP CODE 97601
TELEPHONE 884-3161
AREA CODE 503

February 5, 1981

Kurt Schmidt
Assistant Manager
Modoc Lumber Company
P. O. Box 257
Klamath Falls, OR 97601

Re: Site Plan Review
Modoc Lumber Company
Lots 9 and 10 and the
vacated alley adjoining
said lots, Block 74,
Klamath Addition

Dear Mr. Schmidt:

Enclosed please find a copy of my Decision and Findings in the above referenced matter.

Please be advised that if you object to this decision in whole or in part, you have ten days in which to appeal this decision to the City Planning Commission. The appeal can be initiated by filing a notice of appeal with the City Planning Department.

Sincerely,

Jeffrey D. Ball
Jeffrey D. Ball
City Hearings Officer

JDB:cs
cc: Planning Department
Jim Shreve
Roy Mustoe

SISTER CITY
RUA, NEW ZEALAND

CITY OF KLAMATH FALLS HEARINGS OFFICER

In the Matter of a)
SITE PLAN REVIEW)
)
)
)
MODOC LUMBER COMPANY)
Lots 9 and 10 and the)
vacated alley adjoining)
said lots, Block 74)
Klamath Addition.)
_____)

DECISION AND FINDINGS

THIS MATTER came before the City of Klamath Falls Hearings Officer on February 4, 1981; the Applicant, Modoc Lumber Company, appearing through its Assistant Manager, Kurt Schmidt, and its consultant, Jim Shreve; the City Planning staff appearing through Assistant Planner Karen Lynch; and a neighboring resident, Roy Mustoe, also appearing.

DECISION

BASED UPON THE FINDINGS AND THE CONDITIONS BELOW, the Site Plan for the construction of a pilot plant to pelletize woodwaste for industrial fuel is approved as submitted.

CONDITIONS

- 1) Landscaping. All existing trees on the site shall be preserved.
- 2) Fencing. The proposed fence across the front of the site adjacent to Fourth Street shall be of such construction as not to be detrimental to the aesthetics of the surrounding area. The proposed chain linking with wood slates would be acceptable.
- 3) Air Quality. Discharge of suspended particulate matter, as measured off-site, shall not exceed 60 micrograms per cubic meter of air.
- 4) Noise. Operation of the proposal shall not produce impulsive sound in excess of 80 decibels as measured from any point on Fourth Street.
- 5) Color of Bins. The storage bins shall be painted a neutral color which blends with the surrounding backgrounds.

FINDINGS

In applying the facts to the criteria below, specific cross references have been made; however, the facts separately set forth are generally applicable to numerous criteria and should be treated as cumulative and supplementary.

- 1) Criteria. There is a public need for the requested construction, and the need can best be met by the proposed construction. Sec. 128.003(2), Zoning Ordinance.

Facts. The subject site is zoned M-2, Heavy Industrial, and is located next to the Modoc Lumber steam plant on the site of the Modoc Lumber plant. The proposed use is permitted outright in this zone under the current City Zoning Ordinance.

The pilot plant will use wood shavings produced by the current lumber processing operations at the lumber plant. Conveyors will move the shavings on site to the pilot plant.

The existing single family residence on the site will remain and continue to be rented to a Modoc employee. The garage at the rear of the residence will be remodeled to accommodate the processing equipment and two storage bins will be added near the garage.

Finding. By designating the proposed use as a permitted use in this zone, the Council has already substantially addressed the question of public need. Location of the plant adjacent or on the site where the shavings are produced is necessary to the efficient operation of the proposal. As proposed, the subject site will accommodate the plant with marginal alteration in the existing use and structures. This criteria is satisfied.

2) Criteria. "Citizen Involvement" State-wide Planning Goal #1.

Facts. Notice of the public hearing held February 4, 1981, was published on January 30, 1981, in the Herald and News newspaper. Seventeen adjacent property owners were notified by mail January 30, 1981. No citizen response was received by the Planning Department. During the hearing, testimony was taken of the applicant's representatives and of a neighboring property owner. No other member of the public attended.

Finding. Notice of the public hearing and opportunity to appear and testify having been afforded to the public, this goal has been satisfied.

3) Criteria. "Land Use Planning" State-Wide Planning Goal #2.

Facts. At present, the City does not have an acknowledged comprehensive plan.

Finding. Since the City does not yet have an acknowledged plan, the criteria of this goal are inapplicable. These Findings constitute an interim application of these goals.

4) Criteria. "Agricultural Lands", "Forest Lands", "Open Space, Scenic and Historic Areas, and Natural Resources", State-Wide Planning Goals #3, 4 and 5.

Facts. The site is zoned M-2 and is within the limits of the City. No values associated with any of the above criteria were identified.

Finding. To the extent the goals are applicable, they were met.

5) Criteria. "Air, Water and Land Resource Quality" State-Wide Planning Goal #6.

Facts. The subject site is currently serviced with water from Fourth Street and sewer from a line in Third Street. New consumption is unknown, however, the proposed operation does not utilize water, other than incidental clean-up. No suspended particulates will be washed into the City sewer system. The operation recycles all wood dust produced and all processing will be contained within the "garage" structure.

The wood pellets will be picked up by truck once a day. At present, the wood shavings are trucked to Weyerhaeuser from Modoc daily. Since the proposed operation substantially reduces the bulk of the shavings, there will be a significant decrease in truck traffic.

Drainage catch basins are located at Fourth and Walnut.

Finding. Conditions 3 and 4 limit potential air and noise emissions off site. No adverse affects on water, sewer or drainage are anticipated. These goals are satisfied.

6) Criteria. "Areas Subject to Natural Disasters and Hazards" State-Wide Planning Goal #7.

Facts. The subject property is flat and has no identifiable natural hazard from earthquake, flood or landslide.

Finding. This goal is met.

7) Criteria. "Recreational Needs" and "Housing" State-Wide Planning Goals #8 and #10.

Facts. The proposal consists of alteration of an existing garage and addition of two storage bins. The existing single family residence on the site will continue in its present residential use. No new employment positions will be created. The shavings used for the proposed operation presently are shipped to Weyerhaeuser for production of plywood. Weyerhaeuser will have to find an alternative source.

Finding. The proposal will have no appreciable affect on either of these goals. I am unable to determine whether Weyerhaeuser's loss of access to the shavings will have any potential affect on building materials from the facts presented. These goals are satisfied.

8) Criteria. "Economy of the State" State-Wide Planning Goal #9.

Facts. Construction incident to the proposal has an estimated valuation of \$795,984. Some local contractors may be used in addition to Modoc personnel in the construction of the project. The project has received funding through a Federal grant.

Though capital and operating costs are relatively unknown at this time, Modoc anticipates a greater per unit profit on sale of the wood pellets than it currently realizes on sale of the raw shavings. Locally, wood pellets are burned by the Kingsley Field heat plant, Stukel Rock and Paving in its hot mix operation, and the County schools for space heating. At present, wood pellets must be brought in from Brownsville, Oregon.

No new employment positions will be created.

Weyerhaeuser will have to locate another source of wood shavings.

Facts. The construction and operation of the proposal will result in benefits to the local economy. Outside construction funding may well result in local wages and purchases of materials. Cost of wood pellets to local users need not reflect substantial transportation costs. Modoc should realize increased revenues as will local governments in their property tax revenues. Assuming Weyerhaeuser locates another source of wood shavings from one of the area's lumber plants, the proposal will promote more efficient and complete use of the area's wood resources.

This goal is satisfied.

9) Criteria. "Public Facilities and Services" State-Wide Planning Goal #11.

Facts. Those facts set forth in #5 as they relate to water, drainage, and sanitary sewer are incorporated here.

Fire protection will come from the City's Main station, response time of 2 to 3 minutes estimated. Police protection from the City Police Station on Walnut is immediate.

Finding. Public facilities and services are available at no burden to the public beyond that normally associated with an industrial use. This goal is satisfied.

10) Criteria. "Transportation" State-Wide Planning Goal #12.

Facts. One truck is estimate to be sufficient to pick up the approximately 35 tons of wood pellets produced by the operation daily. Wood shavings will be conveyed on site by conveyor, no street traffic required. The numerous truck trips currently generated in Weyerhaeuser's pick up of the raw wood shavings will be terminated.

The site is adjacent to South Fourth Street, one block removed from South Fifth, a major arterial.

Finding. The servicing streets are more than adequate to handle the one truck trip generated daily. Overall, the proposal will have the affect of decreasing truck traffic in the area of the plant located in the downtown area. This goal is satisfied.

11) Criteria. "Urbanization" State-Wide Planning Goal #14.

Facts. Public services and facilities are readily available (Finding #9 above.) Truck traffic downtown will be decreased (Finding #10 above.) Air and noise contaminants will be minimal (Finding #5 above.)

The single family residence on the site will be retained. Structures (the bins) will be located to the rear and a sight-obscuring fence constructed to shield them from view from Fourth Street. No existing trees will be removed. The storage bins will be painted a neutral color which should blend with the surroundings.

Finding. The proposal, which is an incidental use to the existing lumber plant, has been so designed as to have minimal adverse impacts on the surrounding urban area. Its location promotes efficient use of urban land consistent with existing zoning. This criteria is satisfied.

Dated this 5th day of February, 1981.

J. D. Ball
Jeffrey D. Ball, City Hearings Officer

Appendix F

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY NOTICE OF APPROVAL
FOR PILOT PLANT

Department of Environmental Quality

522 SOUTHWEST 5TH AVE. PORTLAND, OREGON

MAILING ADDRESS: P.O. BOX 1760, PORTLAND, OREGON 97207

To: • Modoc Lumber Company
P.O. Box 257
Klamath Falls, OR 97601

Attn: Kurt Schmidt

Date: May 21, 1981

File Reference: NC 1755
18-0009

Department action as indicated below has been taken on your Notice of Intent to Construct and Request(s) for Construction Approval and/or Preliminary Certification for tax credit for the proposed facility.

<u>Project</u>	<u>Project Description</u>	<u>Plans & Specifications Identification</u>
NC 1755	Installation of target box and bins associated with wood pelletizing facility.	Notice of Construction received on May 20, 1981.

PLANS AND SPECIFICATIONS AND CONSTRUCTION APPROVAL

☒ - APPROVED - Subject to the conditions listed on the reverse side.

Plans and Specifications reviewed by: Robert Danko

PRELIMINARY CERTIFICATION FOR TAX CREDIT OF A POLLUTION CONTROL FACILITY

☐ - APPROVED - This preliminary certification makes the proposed facility eligible for consideration for tax credit but does not insure that any specific part or all of the pollution control facility will be issued a tax credit certificate.

Tax Credit review by: _____

If the Department can be of assistance, or if there are any questions, please contact:

Name: Robert Danko Title: Regional Engineer Phone: 382-6446

Sincerely,

Richard J. Nichols
Regional Manager

PLANS AND SPECIFICATIONS AND CONSTRUCTION APPROVAL CONDITIONS

1. The construction of the project shall be in strict conformance to approved plans and specifications identified above. No changes or deviations shall be made without prior written approval of the Department of Environmental Quality. (Air contaminant facilities are subject to confirmation by the Environmental Quality Commission.)
2. Granting approval does not relieve the owner of the obligation to obtain required local, state and other permits and to comply with the appropriate statutes, Administrative Rules, Standards, and if applicable, to demonstrate compliance.
3. Please fill out and return the enclosed Notice of Construction Completion form within 30 days upon completion of this approved project.
4. Department personnel shall inspect the target box for visual compliance with permit conditions. Modifications will be required if emissions are above permit limits.

State of Oregon
Department of Environmental Quality
P.O. Box 1760
Portland, Oregon 97207

NOTICE OF APPROVED CONSTRUCTION COMPLETION

To: Owner or Applicant

This form must be filled in and returned within 30 days upon completion of the approved construction.

Mail to: Department of Environmental Quality
P. O. Box 1760
Portland, Oregon 97207

Attention: ☒ Air Quality Division
☐ Water Quality Division
☐ Solid Waste Division

The facility described below was completed on _____,
(date)
and was or will be in operation _____.
(date)

(signature) (title) (date)

Please send tax credit application for this project ☐ yes ☐ no.

(For DEQ use only - below this line)

Applicant Name Modoc Lumber Company Request No. NC 1755

Address P.O. Box 257 File No. 18-0009

City & Zip Code Klamath Falls, Oregon 97601

Description of Facility Installation of target box and bins associated with wood
pelletizing facility.

Date Notice Received _____

Assigned for Inspection to _____ by _____ on _____

Date of Inspection Report _____ by _____

Summary of Inspection:

Date cc to E.I. _____ ☐ Attachments

Appendix G

PROJECT NOISE DATA

Pre-operation ambient noise levels were measured at four points along the plant boundary line using the methodology prescribed by the Oregon Department of Environmental Quality. Noise levels were recorded at each station at ten second intervals over a 20-minute period. All levels were recorded using an A-weighted scale. The results of the survey are summarized in Table 1.

Sites 1 and 2 along 4th Street tend to show lower noise levels than 3 and 4 adjacent to Klamath Avenue. This is due to the noticeably higher traffic flow along Klamath Avenue. However, due to a recently adopted City ordinance directly truck traffic onto 4th Street, a significant increase in truck related noise on 4th can be expected in the near future. This increase is expected to raise instantaneous noise level peaks to 75-80 dBA.

Operational noise levels were measured at the same four locations as above using the same methodology. Results are summarized in Table 2.

Noise levels recorded during pelleting operations are only slightly higher than pre-operation measurements. It is believed that these nominal increases are due partially to increased truck traffic on 4th Street, as well as pelleting operations.

Detailed noise survey data is presented in the following Department of Environmental Quality worksheets.

Table 1

PRE-OPERATION NOISE SUMMARY

<u>% of Time</u> <u>Level is Exceeded</u>	<u>Sound Pressure Level (dBA)</u>			
	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>
100	54	55	58	53
90	57	57	59	55
50	63	59	65	64
10	66	63	72	70
0	69	76	80	74

Table 2
POST-OPERATION NOISE SUMMARY

<u>% of Time</u> <u>Level is Exceeded</u>	<u>Sound Pressure Level (dBA)</u>			
	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>
100	64	65	66	67
90	66	67	71	69
50	67	69	73	73
10	69	75	76	75
0	80	79	84	78

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL NOISE SURVEY

LOCATION: #1 Modoc Lumber Co Pellet Plant BY: J.S.

PRIMARY SOURCE: Traffic - direct, minimal, noise DATE: 8/3/81

primarily from nearby main street (Klamath Ave) SHEET: 1 / 3

SECONDARY SOURCE: cat spreading hogged fuel at modoc, & other mill related noises.

SAMPLE INTERVAL: 5 10 15 SECONDS

START TIME: 4:00 "A" MIN. MAX. CENT. TEND.
SCALE: 60 | 70 |

Time	Calibration dB	F dry bulb	F wet bulb	ZRH	Press. mm Hg.	Wind MPH	Wind direct.
3:36	OK 113.1						

INSTRUMENTION		
EQU	TYPE	SERIAL
SLM	GR 1565-C	29240
MIC		
CAL	GR 1567	17106
WINDSCREEN: <u>ON</u> OFF		
R. I. C: ON OFF		

Data Points

SOUND PRESSURE LEVEL dBA

1 - 8	65	62	59	61	70	70	61	57
9 - 16	57	65	64	60	59	60	62	64
17 - 24	63	60	57	57	62	61	62	59
25 - 32	59	63	61	62	61	59	60	63
33 - 40	67	60	67	64	62	62	65	62
41 - 48	69	59	60	59	62	62	55	55
49 - 56	55	57	59	55	57	58	60	63
57 - 64	62	61	62	67	60	61	65	67
65 - 72	66	66	66	65	65	65	62	63
73 - 80	62	64	66	65	66	66	67	65
81 - 88	65	66	64	64	62	62	66	63
89 - 96	61	62	65	66	66	66	67	67
97 - 104	64	60	62	67	67	63	67	66
105 - 112	62	65	66	61	66	63	65	62
113 - 120	62	66	62	66	62	61	57	67
121 - 128	66	64	65	63	64	62	64	65
129 - 136								
137 - 144								
145 - 152								

Note: A minimum of 120 data points are required.

Indicate all missed data points and an explanation.

Figure 4-7 Form NPC-10-1 Statistical Noise Survey

Page 1 of 3

NPC-10-1

STATISTICAL COMPUTATION SHEET

DATE 3/4/97

SHEET 2 of 2

FIGURE 4-8 FORM NPCS-10-2 STATISTICAL COMPUTATION SHEET

NPCS-10-2

$L_{100} = 54$ $L_{10} = 66$
 $L_{90} = 57$ $L_0 = 69$
 $L_{50} = 63$

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY Shreve DATE 8/4 SOURCE #1 Mobile Lumber Co. Prop ambient

FIGURE 4-9 FORM NPCCS-10-3 STATISTICAL NOISE GRAPH

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL NOISE SURVEY

LOCATION: Modoc Pellet Plant BY: J.S.

PRIMARY SOURCE: Traffic DATE: 8/3/21

SHEET: 1 / 3

SECONDARY SOURCE: Winery - Modoc Lumber Co. Steam Plant

SAMPLE INTERVAL: 5 10 15 SECONDS
 START TIME: 3:37 "A" MIN. MAX. CENT. TEND.
 SCALE: 60 71

Time	Calibration dB	F dry bulb	F wet bulb	ZRH	Press. mm Hg.	Wind MPH	Wind direct.
336	113.1						

INSTRUMENTATION		
EQU	TYPE	SERIAL
SLM	62	27240
MIC		
CAL	62	17106
WINDSCREEN: <u>ON</u> OFF		
R. I. C. ON OFF		

Data Points

SOUND PRESSURE LEVEL dBA

1 - 8	64	59	62	64	60	60	64	59
9 - 16	58	57	60	59	70	59	60	57
17 - 24	59	59	60	62	60	57	57	60
25 - 32	60	58	59	64	60	58	62	57
33 - 40	58	70	60	59	59	59	58	58
41 - 48	56	57	59	57	59	60	57	60
49 - 56	56	59	59	59	59	62	59	61
57 - 64	60	60	58	65	63	58	58	61
65 - 72	59	62	58	64	59	59	70	62
73 - 80	60	59	65	58	59	58	60	75
81 - 88	58	59	58	58	63	65	58	58
89 - 96	59	60	58	59	58	62	59	62
97 - 104	60	59	62	57	62	58	60	58
105 - 112	59	58	59	62	59	60	62	61
113 - 120	60	61	59	57	58	58	58	59
121 - 128	60	59	57	59	59	58	59	59
129 - 136								
137 - 144								
145 - 152								

Note: A minimum of 120 data points are required.

Indicate all missed data points and an explanation.

Figure 4-7 Form NPC-10-1 Statistical Noise Survey
 Page 1 of 3

NPCS-10-1

STATISTICAL COMPUTATION SHEET

BY JS

DATE 8/4

LOCATION #2 Modoc Pellet Plant

SHEET 2 of 3

FIGURE 4-8 FORM NPCS-10-2 STATISTICAL COMPUTATION SHEET

NPCS-10-2

L₁₀₀ = 55

L₁₀ = 63

L₅₀ = 57

L₀ = 76

L₅₀ = 59

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY Shreve

DATE 8/4

SOURCE #2
Maloc Lumber Co Mill Plant, Preop ambient

FIGURE 4-9 FORM NPCS-10-3 STATISTICAL NOISE GRAPH

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL NOISE SURVEY

LOCATION: 3 BY: J.S.
 PRIMARY SOURCE: Traffic DATE: 8/3/81
 SHEET: 1 / 3

SECONDARY SOURCE: _____

SAMPLE INTERVAL: 5 10 15 SECONDS
 "A" MIN. MAX. CENT. TEND.
 START TIME: 3:13 SCALE: 70 | 80 | _____

Time	Calibra- tion dB	F dry bulb	F wet bulb	2RH	Press. mm Hg.	Wind MPH	Wind direct.

INSTRUMENTION		
EQU	TYPE	SERIAL
SLM	OR 1/5496	29240
MIC		
CAL	OR 1/5497	17106
WINDSCREEN: ON/OFF		
R. I. C: ON OFF		

Data Points

SOUND PRESSURE LEVEL dBA

1 - 8	60	62	70	64	71	68	66	61
9 - 16	70	65	61	67	67	68	71	70
17 - 24	67	70	70	60	62	64	65	68
25 - 32	60	65	69	70	62	70	70	64
33 - 40	67	60	71	75	69	67	73	57
41 - 48	62	63	64	59	69	59	62	72
49 - 56	73	67	69	75	71	64	73	59
57 - 64	65	70	75	70	58	60	62	65
65 - 72	66	60	60	63	58	59	59	77
73 - 80	70	59	60	65	62	71	59	67
81 - 88	71	59	65	60	59	66	62	67
89 - 96	68	70	72	62	77	65	62	62
97 - 104	68	76	73	62	77	65	65	67
105 - 112	77	77	65	69	67	76	65	67
113 - 120	65	60	67	65	75	62	65	71
121 - 128	62	65	60	68	60	67	62	62
129 - 136								
137 - 144								
145 - 152								

Note: A minimum of 120 data points are required.

Indicate all missed data points and an explanation.

Figure 4-7 Form NPCS-10-1 Statistical Noise Survey
 Page 1 of 3

NPCS-10-1

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL COMPUTATION SHEET

BY JSDATE 3/4/77LOCATION #3 Modoc Pella PlantSHEET 2 of 3

LEVEL dBA	TALLY	No. Readings	No. .GT.	% .GT.
55				
56				
57				
58		2	126	93.4
59		9	117	91.9
60		13	104	81.3
61		2	102	79.7
62		13	89	69.5
63		2	87	68.0
64		5	82	64.1
65		16	66	51.6
66		3	63	49.2
67		14	49	33.3
68		6	43	33.6
69		7	36	28.1
70		13	23	18.0
71		7	16	12.5
72		2	14	10.9
73		5	9	7.0
74		0	9	7.0
75		4	5	3.9
76		2	3	2.3
77		2	1	0.8
78		0	1	0.8
79		0	1	0.8
80		1	0	0.0
Total		128		

FIGURE 4-8 FORM NPCS-10-2 STATISTICAL COMPUTATION SHEET

NPCS-10-2

L₁₀₀ = 58

L₁₀ = 72

L₉₀ = 59

L₀ = 80

L₅₀ = 65

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY JS

DATE 8/4

SOURCE

site # 3 modoc Pellet Plant (reoperation levels) ^{ambient}

FIGURE 4-9 FORM NPC-10-3 STATISTICAL NOISE GRAPH

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL NOISE SURVEY

LOCATION: #4 BY: J.S.
 PRIMARY SOURCE: Traffic DATE: 8/3/81
 SHEET: 1 / 3

SECONDARY SOURCE: _____

SAMPLE INTERVAL: 5 (10) 15 SECONDS
 "A" MIN. MAX. CENT. TEND.
 START TIME: 2:50 SCALE: 60 | 70 | _____

Time	Calibra- tion dB	F dry bulb	F wet bulb	2RH	Press. mm Hg.	Wind MPH	Wind direct.
248	✓ 113.1	.					

INSTRUMENTION		
EQU	TYPE	SERIAL
SLM	62 15555	29240
MIC		
CAL	62 15555	17106
WINDSCREEN: <u>(ON)</u> OFF		
R. I. C: ON OFF		

Data Points

SOUND PRESSURE LEVEL dBA

1 - 8	71	62	74	60	72	71	70	70
9 - 16	62	60	73	63	69	60	70	63
17 - 24	65	60	60	70	62	65	73	60
25 - 32	65	62	60	59	60	71	60	67
33 - 40	52	40	67	60	59	60	70	67
41 - 48	62	59	57	56	67	59	70	64
49 - 56	66	66	56	56	59	62	65	70
57 - 64	57	67	64	64	66	70	71	62
65 - 72	57	69	67	58	61	58	58	64
73 - 80	67	71	60	69	59	57	58	59
81 - 88	63	64	65	60	68	65	59	60
89 - 96	68	58	62	64	68	71	71	66
97 - 104	67	57	71	58	58	71	65	63
105 - 112	70	65	62	71	60	67	71	60
113 - 120	64	71	63	57	71	57	57	59
121 - 128	59	71	62	60	69	71	71	58
129 - 136								
137 - 144								
145 - 152								

Note: A minimum of 120 data points are required.

Indicate all missed data points and an explanation.

Figure 4-7 Form NPC-10-1 Statistical Noise Survey
 Page 1 of 3

NPCS-10-1

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL COMPUTATION SHEET

LOCATION #4 Madoc Pellet Plant

BY JS

DATE 3/4/82

SHEET 2 of 3

LEVEL dBA	TALLY	No. Readings	No. GT.	% GT.
55		0		
56		3	125	97.7
57		8	117	91.4
58		7	110	85.9
59		9	101	78.9
60		18	33	54.8
61		1	32	64.1
62		8	74	57.8
63		5	69	53.9
64		7	62	48.4
65		8	54	42.2
66		5	49	38.3
67		8	41	32.0
68		7	34	26.6
69		5	29	22.7
70		9	20.0	15.6
71		16	4	3.1
72		1	3	2.3
73		2	1	0.8
74		1	0	0.0
75		0		
		542	128	

FIGURE 4-8 FORM NPC-10-2 STATISTICAL COMPUTATION SHEET

NPC-10-2

$L_{100} = 53$

$L_{10} = 70$

$L_{90} = 55$

$L_0 = 74$

$L_{50} = 63.5$

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY JS

DATE 8/4

SOURCE Marine Bell Mill #4 - Recop ambient level

FIGURE 4-9 FORM NPC-10-3 STATISTICAL NOISE GRAPH

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL NOISE SURVEY

LOCATION: *1 Mendocino Co Pallet Plant #1 BY: ALEX S. FORD (AS)

PRIMARY SOURCE: Traffic - direct, 1/2 construction in corner of DATE: 1/13/82

Highway 101 near Main St. (Klamath Ave) Suisun, Calif. SHEET: 1 / 3

SECONDARY SOURCE: Other selected noises

SAMPLE INTERVAL: (5) 10 15 SECONDS

START TIME: 11:01 "A" MIN. MAX. CENT. TEND.
SCALE: 60 70

Time	Calibration dB	F dry bulb	F wet bulb	%RH	Press. mm Hg.	Wind MPH	Wind direct.

INSTRUMENTION		
EQU	TYPE	SERIAL
SLM	1/5201	
MIC		
CAL		
WINDSCREEN: ON OFF		
R. I. C: ON OFF		

Data Points

SOUND-PRESSURE LEVEL dBA

1 - 8	69	68	67	69	68	67	69	67
9 - 16	67	69	68	72	68	67	68	62
17 - 24	69	68	67	68	68	67	68	77
25 - 32	69	68	67	69	67	68	67	61
33 - 40	66	69	68	69	67	66	67	61
41 - 48	67	69	67	68	69	68	67	62
49 - 56	68	68	66	69	67	68	67	66
57 - 64	68	74	75	65	72	68	71	61
65 - 72	68	67	67	67	67	68	67	67
73 - 80	67	66	68	67	67	67	67	68
81 - 88	66	68	67	67	67	67	67	65
89 - 96	72	69	65	68	68	67	67	60
97 - 104	68	67	68	68	68	67	67	62
105 - 112	67	67	68	68	69	68	67	65
113 - 120	69	67	68	67	67	66	67	67
121 - 128	65	60	67	66	68	65	67	69
129 - 136								
137 - 144								
145 - 152								

Note: A minimum of 120 data points are required.

Indicate all missed data points and an explanation.

Figure 4-7 Form NPCS-10-1 Statistical Noise Survey

Page 1 of 3

STATISTICAL COMPUTATION SHEET

BY AS

DATE 1/15

SHEET 204

LOCATION

FIGURE 4-8 FORM NPCS-10-2, STATISTICAL COMPUTATION SHEET
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NPCS-10-2

64.6 < 100
 66 < 90
 67 < 50
 69 < 10
 80 < 0

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY AS DATE 1/15 SOURCE Monroe Pellet Plant operational #1

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL NOISE SURVEY

LOCATION: 1.100 PENET ROAD #2 BY: J.S.

PRIMARY SOURCE: Sump, pump & construction of district DATE: 11/3/82

Repeating line approx. 55 feet west SHEET: 1 / 3

SECONDARY SOURCE: bullet plant, steam plant traffic

SAMPLE INTERVAL: (5) 10 15 SECONDS
 START TIME: 11:20 "A" MIN. MAX. CENT. TEND.
 SCALE: 60 80

Time	Calibra- tion dB	F dry bulb	F wet bulb	ZRH	Press. mm Hg.	Wind MPH	Wind direct.

INSTRUMENTION	
EQU TYPE	SERIAL
SLM	4056
MIC	
CAL	
WINDSCREEN:	ON OFF
R. I. C:	ON OFF

Data Points

SOUND PRESSURE LEVEL dBA

1 - 8	74	72	74	73	77	75	72	74
9 - 16	72	75	74	74	75	74	72	74
17 - 24	72	75	74	72	74	72	74	73
25 - 32	77	75	74	74	72	74	75	79
33 - 40	76	74	76	72	75	72	72	75
41 - 48	72	75	72	74	72	74	71	72
49 - 56	74	75	75	75	77	74	76	71
57 - 64	72	72	72	64	64	72	62	65
65 - 72	72	65	65	65	68	69	67	65
73 - 80	72	65	65	65	65	67	62	65
81 - 88	68	67	65	66	65	65	67	65
89 - 96	65	65	65	67	67	65	65	66
97 - 104	65	65	62	67	65	65	67	65
105 - 112	68	65	65	67	67	65	65	65
113 - 120	68	68	62	67	65	65	71	64
121 - 128	68	65	65	69	67	67	65	66
129 - 136								
137 - 144								
145 - 152								

Note: A minimum of 120 data points are required.

Indicate all missed data points and an explanation.

Figure 4-7 Form NPC-10-1 Statistical Noise Survey

Page 1 of 3

NPC-10-1

STATISTICAL COMPUTATION SHEET

BY 45

DATE 1/15/57

SHEET 204

FIGURE 4-8 FORM NPCS-10-2 STATISTICAL COMPUTATION SHEET

NPCS-10-2

65 < 100
 67 < 90
 69 < 50
 75 < 10
 79 < 0

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY AS DATE 1/15/82 SOURCE Noise Pellet Plant #2

DEPARTMENT OF ENVIRONMENTAL QUALITY

STATISTICAL NOISE SURVEY

LOCATION: Minne Pilot Mill #3 BY: AS
 PRIMARY SOURCE: Thalys in Klamath Ave DATE: 1/13/51
 SHEET: 1 / 3

SECONDARY SOURCE: PILOT MILL

SAMPLE INTERVAL: (5) 10 15 SECONDS
 "A" MIN. MAX. CENT. TEND.
 START TIME: 11:40 SCALE: _____

Time	Calibra- tion dB	F dry bulb	F wet bulb	%RH	Press. mm Hg.	Wind MPH	Wind direct.

INSTRUMENTION	
EQU	TYPE SERIAL
SLM	<u>905B</u>
MIC	
CAL	
WINDSCREEN: ON OFF	
R. I. C: ON OFF	

Data Points

SOUND PRESSURE LEVEL dBA

1 - 8	70	74	67	70	71	73	71	74
9 - 16	73	70	75	74	72	72	76	74
17 - 24	74	73	76	71	75	76	74	77
25 - 32	70	73	75	76	72	74	72	73
33 - 40	76	77	74	73	75	76	74	77
41 - 48	74	76	74	75	77	73	75	72
49 - 56	76	73	73	74	75	75	74	72
57 - 64	72	75	72	77	72	76	77	77
65 - 72	74	75	73	74	70	76	75	74
73 - 80	73	74	73	73	74	74	73	72
81 - 88	72	78	72	71	69	71	73	74
89 - 96	73	74	73	73	72	74	75	72
97 - 104	73	74	73	75	73	73	75	76
105 - 112	73	73	73	74	74	75	74	73
113 - 120	74	74	73	75	75	76	75	77
121 - 128	75	74	78	79	75	76	72	72
129 - 136								
137 - 144								
145 - 152								

Note: A minimum of 120 data points are required.

Indicate all missed data points and an explanation.

Figure 4-7 Form NPC-10-1 Statistical Noise Survey

Page 1 of 3

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NPCS-10-1

BY _____

DATE _____

SHEET 2 of 2

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66 < 100 dB
 71 < 90
 73 < 50
 76 < 10
 84 < 0

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY AS DATE 1/18/82 SOURCE Modac Pellet Plant #3

STATISTICAL NOISE SURVEY

SECONDARY SOURCE: James Earl Ray, letter, 1/28/68
inil memo

SAMPLE INTERVAL: 5 10 15 SECONDS				
START TIME: 4:62		"A" SCALE: 60	MIN. 70	MAX. CENT. TEND.

[illegible]

INSTRUMENTION
EQUOT TYPE SERIAL
SLM <i>405B</i>
MIC
CAL
WINDSCREEN: ON OFF
R. I. C: ON OFF

SOUND PRESSURE LEVEL dBA

1 - 8	70	68	65	67	70	73	71	74
9 - 16	75	74	75	76	73	72	73	76
17 - 24	71	74	75	71	74	75	73	75
25 - 32	72	75	74	73	75	75	76	73
33 - 40	72	69	69	66	72	71	70	74
41 - 48	70	72	74	72	74	73	73	74
49 - 56	65	69	69	68	70	75	73	73
57 - 64	72	75	73	76	75	73	72	74
65 - 72	74	74	76	73	73	73	73	76
73 - 80	73	72	75	75	72	74	74	73
81 - 88	75	73	73	74	73	75	73	75
89 - 96	75	73	74	75	75	75	74	75
97 - 104	74	71	75	72	75	77	75	74
105 - 112	74	76	76	75	74	72	71	76
113 - 120	73	75	73	75	74	74	76	74
121 - 128	71	73	72	74	73	75	75	77
129 - 136								
137 - 144								
145 - 152								

Indicate all missed data points and an explanation.

NPCS-10-1

BY _____
DATE _____

SHEET 22

FIGURE 4-8 FORM NPCS-10-2 STATISTICAL COMPUTATION SHEET
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NPCS-10-2

67 < 100
 69 < 90
 73 < 50
 75 < 10
 78 < 0

STATISTICAL NOISE SURVEY

Sheet 3 of 3

BY AS DATE 1/15/82 SOURCE W/encoc Permit Permit #4

Appendix H

TRIAL OPERATION PELLET TESTS

OREGON INSTITUTE OF TECHNOLOGY

KLAMATH FALLS, OREGON 97601

TELEPHONE (503) 882-6321

October 12, 1981

Mr. Kurt Schmidt
Modoc Lumber Company
4th and Oak Streets
Klamath Falls, OR 97601

Dear Mr. Schmidt:

I have completed a total of seven tests of your Sample No. 1. The first four tests produced widely scattered results: from approximately 3500 Btu/lb to 9600 Btu/lb with an average of 9100 Btu/lb. Those test results, so scattered that I've discarded them, left me no alternative but to retest. I found and corrected two sources of error in procedure and constructed a much better cooler with which to maintain the cold water supply to the calorimeter. Our campus cold water has an average temperature near 85°F at Cornett Hall and the calorimeter requires a cold water supply not warmer than 55°F. The cooler used in the first four tests delivered water at marginally satisfactory and continuously varying temperature.

Three test runs, reports enclosed, performed October 9 produced very satisfactory results. I reported these three results to you by telephone today as 8494.13, 8499.95 and 8565.32 Btu/lb. The test report values enclosed differ from the telephoned values by a small amount as a result of thermometer corrections applied after our telephone conversations.

It pleases me to report that the total spread of values, largest value minus least value ($8571.01 - 8503.04 = 67.97$), is only 8/10ths of one percent of the least value.

You will note that the gross heating value is reported. I've not reported the net heating value. The net heating value is simply the gross heating value corrected for the heat of formation of Nitric and Sulfuric acids. To make these corrections requires knowledge of the sulfur content of the fuel and a tedious titration. These corrections constitute 14 calories per gram of sample per percent of sulfur in the sample and about 18 to 22 calories resulting from oxidation of nitrogen in the air content of the bomb (and nitrogen content of sample) before charging with oxygen. Since typical chemical analyses of wood show only trace amounts of sulfur, that correction can be neglected if you do not add any sulfur-containing compound during pellet manufacture. One may minimize the amount of nitrogen in the bomb's air content by bleeding oxygen through the bomb prior to sealing and pressurizing. Twenty-two calories per sample is a typical correction for a test conducted at sea level with no oxygen bleed. To make the nitrogen oxide (Nitric Acid) correction would require at least one additional hour per test and would reduce the gross heating value reported by, at most, 22 calories per sample (and if the sample were 1.5 grams, 15 cal/gram) or 26 Btu/lb, about 3/10ths of 1 percent.

Kurt Schmidt

-2-

October 12, 1981

For your information, both the gross heating value and net heating value, if determined, are higher heating values. That is, water formed during combustion of the hydrogen in the sample is initially vapor but then condenses on the inner walls of the bomb, giving up the heat of condensation to the bucket water. Lower heating values, often reported in the literature, are the result of recognition that water formed in a typical combustion process leaves the process as vapor, carrying the heat of vaporization (condensation) away with it.

I believe the results reported here do not differ from the true values by more than 2% (traceable to experimental uncertainties) and may be as good as 1%. I've enclosed for your comparison some typical heating values for woods from an old reference work.

From the standpoint of your development work, a far more important discrepancy can result from the water content of your samples. If, for example, the sample just tested contained 10% moisture (a reasonable air-dry value), the Run #1 value reported here would, when corrected to a bone-dry basis, be:

$$\begin{aligned} H_g &= \frac{(2.761)(2420) - (9.5)(2.3)}{1.4098 \times .90} \times 1.8 \\ &= 9447.82 \text{ Btu/lb.} \end{aligned}$$

The key reason that my initial results were so widely scattered was the variation in water content of individual chunks of material. Consideration should be given to the determination of moisture content in future tests.

Dr. Lund has informed you that there is a problem resulting from administrative rules that forbid a faculty member from using institutional equipment in outside work for pay. I've asked Dr. Light for a ruling in this matter and I trust he will find a way to accommodate your needs.

For these initial tests, we can avoid any controversy by performing them as a public service without fee. Please do not be concerned about the time I've devoted to these tests. I've learned a good bit through the work. Three weeks from today I shall be teaching 38 MET students of junior standing how to make heating value determinations with this same equipment. As a result of these tests, you can safely wager that my instruction will be relevant. As a matter of fact, I've bottled for posterity and future classes about 1/2 liter of your Sample No. 1. It is the first in what I hope one day to be a large collection of fuels and foods gathered from around the world for energy determinations.

Sincerely,

Wayne E. Phillips, Department Chairman
Mechanical Engineering Technology

WEP:bjy

Enclosures

cc: Dr. K. Light
Dr. W. Smith
Dr. J. Lund

CALORIMETER TEST REPORT

Calorimeter: Parr Adiabatic Model 1241
Serial No. 2456, Thermometer #3K7240
Energy Equivalent 2420 Cal/°C

Test Date October 9, 1981

Test Operator W. E. Phillips

MATERIAL TESTED: Compressed wood pellets from Ponderosa Pine (yellow pine)
mill wastes identified as Modoc Lumber Co. Sample No. 1. Tests performed on
"air-dry" "as-received" pellets. Compositional analysis not known.

MATERIAL COMPOSITION:

% Carbon ? % Hydrogen ? % Sulfur ? % Water ? % Ash ? % Other ?

RUN NO. 1

Fuel Cup wt, Full, grams..... 13.3304 $T_f^{\circ}\text{C}$ read 27.111 $T_{f\text{corrected}}$ 27.123 °C

Fuel Cup wt, Tare (Empty).... - 11.9206 $T_a^{\circ}\text{C}$ read 24.351 $T_{a\text{corrected}}$ -24.362 °C

Net Fuel, grams..... 1.4098 Δt 2.761 °C

Net Fuse Wire Burned 9.5 cm Fuse Wire Heating Value 2.3 Cal/cm

Alkali Titrant Not performed ml

Gross Heating Value, H_g : .0725 Normal

$$H_g = \frac{(\Delta t^{\circ}\text{C})(\text{Energy Equivalent}) - (\text{Fuse Wire, cm})(\text{Fuse Wire HV})}{\text{Net Fuel, grams}} = \text{Calories/gram}$$

$$H_g = \frac{(2.761^{\circ}\text{C})(2420) - (9.5)(2.3)}{(1.4098)} = 4723.91 \text{ Cal/gm}$$

$$H_g \times 1.8 = 8503.04 \text{ Btu/lb}$$

Net Heating Value, H_N = Not determined Cal/gm Btu/#

$$H_N = \frac{(\Delta t^{\circ}\text{C})(\text{Energy Equivalent}) - (\text{Fuse Wire, cm})(\text{Fuse Wire HV}) - e_1 - e_2}{\text{Fuel Sample wt, grams}}$$

where: e_1 = Correction in calories for heat of formation of nitric acid
= Milliliters Alkali Titrant used

e_2 = Correction in calories for heat of formation of sulfuric acid
= (% Sulfur in Sample)(Fuel Sample wt)(14)

W. Phillips:bjy
10/13/81

CALORIMETER TEST REPORT

Calorimeter: Parr Adiabatic Model 1241
 Serial No. 2456, Thermometer #3K7240
 Energy Equivalent 2420 Cal/°C

Test Date October 9, 1981

Test Operator W. E. Phillips

MATERIAL TESTED: See Run 1, same material.

MATERIAL COMPOSITION:

% Carbon _____ % Hydrogen _____ % Sulfur _____ % Water _____ % Ash _____ % Other _____

RUN NO. 2

Fuel Cup wt, Full, grams..... 13.7204 $T_f^{\circ}\text{C}$ as read 28.128 $T_f^{\circ}\text{C}$ corrected 28.143 °C

Fuel Cup wt, Tare (Empty).... - 12.0194 $T_a^{\circ}\text{C}$ as read 24.803 $T_a^{\circ}\text{C}$ corrected -24.814 °C

Net Fuel, grams..... 1.7010 Δt 3.329 °C

Net Fuse Wire Burned 8.5 cm Fuse Wire Heating Value 2.3 Cal/cm

Alkali Titrant Not performed ml

Gross Heating Value, H_g : .0725 Normal

$$H_g = \frac{(\Delta t^{\circ}\text{C})(\text{Energy Equivalent}) - (\text{Fuse Wire, cm})(\text{Fuse Wire HV})}{\text{Net Fuel, grams}} = \text{Calories/gram}$$

$$H_g = \frac{(3.329^{\circ}\text{C})(2420) - (8.5)(2.3)}{(1.7010)} = 4724.65 \text{ Cal/gm}$$

$$H_g \times 1.8 = 8504.37 \text{ Btu/lb}$$

Net Heating Value, H_N = Not determined Cal/gm _____ Btu/#

$$H_N = \frac{(\Delta t^{\circ}\text{C})(\text{Energy Equivalent}) - (\text{Fuse Wire, cm})(\text{Fuse Wire HV}) - e_1 - e_2}{\text{Fuel Sample wt, grams}}$$

where: e_1 = Correction in calories for heat of formation of nitric acid
 = Milliliters Alkali Titrant used

e_2 = Correction in calories for heat of formation of sulfuric acid
 = (% Sulfur in Sample)(Fuel Sample wt)(14)

W. Phillips:bjy
 10/13/81

CALORIMETER TEST REPORT

Calorimeter: Parr Adiabatic Model 1241
 Serial No. 2456, Thermometer #3K7240
 Energy Equivalent 2420 Cal/°C

Test Date October 9, 1981
 Test Operator W. E. Phillips

MATERIAL TESTED: See Run 1.

MATERIAL COMPOSITION:

% Carbon _____ % Hydrogen _____ % Sulfur _____ % Water _____ % Ash _____ % Other _____

RUN NO. 3

Fuel Cup wt, Full, grams..... 13.4541 $T_f^{\circ}\text{C}$ read 27.455 $T_{f\text{corrected}}$ 27.468 °C

Fuel Cup wt, Tare (Empty).... - 11.9216 $T_a^{\circ}\text{C}$ read 24.434 $T_{a\text{corrected}}$ -24.445 °C

Net Fuel, grams..... 1.5325 Δt 3.023 °C

Net Fuse Wire Burned 8.0 cm Fuse Wire Heating Value 2.3 Cal/cm

Alkali Titrant Not performed ml

Gross Heating Value, H_g : .0725 Normal

$$H_g = \frac{(\Delta t^{\circ}\text{C})(\text{Energy Equivalent}) - (\text{Fuse Wire, cm})(\text{Fuse Wire HV})}{\text{Net Fuel, grams}} = \text{Calories/gram}$$

$$H_g = \frac{(3.023^{\circ}\text{C})(2420) - (8.0)(2.3)}{(1.5325)} = 4761.67 \text{ Cal/gm}$$

$$H_g \times 1.3 = 8571.01 \text{ Btu/lb}$$

Net Heating Value, H_N = Not determined Cal/gm _____ Btu/#

$$H_N = \frac{(\Delta t^{\circ}\text{C})(\text{Energy Equivalent}) - (\text{Fuse Wire, cm})(\text{Fuse Wire HV}) - e_1 - e_2}{\text{Fuel Sample wt, grams}}$$

where: e_1 = Correction in calories for heat of formation of nitric acid
 = Milliliters Alkali Titrant used

e_2 = Correction in calories for heat of formation of sulfuric acid
 = (% Sulfur in Sample)(Fuel Sample wt)(14)

W. Phillips:bjy
 10/13/81

TYPICAL HEATING VALUES FOR WOODS*

WEP 10/9/81

<u>Wood</u>	<u>Wt per Cord, Air Dry, lbs.</u>	<u>Heating Value, Air Dry, Btu/lb.**</u>
Ash, White	3800	5395
Beech	3900	5359
Birch, Yellow	4000	5225
Chestnut	2700	5778
Cottonwood	2500	6000
Elm, White	3100	5710
Hickory	4600	5391
Maple, Sugar	3900	5590
Maple, Red	4700	5969
Oak, Red	3900	5564
Oak, White	4300	5558
Pine, Yellow	2300	9174
Pine, White	2200	5864
Walnut, Black	4000	4650
Willow	2300	5870

*From Kent, Mechanical Engineers' Handbook, Eleventh Edition,
Power Volume, 1937.

**Air dry is stated in this reference to be as much as 25% water.

MODOC LUMBER CO.
Pellet Plant Test Results

Moisture and density samples - September 2, 1981

<u>Sample #</u>	<u>Description</u>	<u>Moisture Content</u> <u>(% by dry weight)</u>
1.	Shavings before hammer mill	8.6%
2.	Fines after hammer mill	8.6%
3.	Fines in steam just before press	11.9%
4.	Pellets falling out of press	8.3%
5.	Pellets after cooling	6.0%

Bulk (loose) density

both samples taken as pellets after cooling

sample #1 = 34.1 pcf

sample #2 = 34.4 pcf

Temperatures

several temperature readings were attempted, but generally unsuccessful
dial gauge on press = 174° F

temperature through door in top of press = 165° F (questionable reading)

Note: loose density samples were poured into 0.1 and 0.5 cf containers.

John W. Lund
Civil Engineer

MODOC LUMBER CO.
Pellet Plant Test Results

Moisture and density samples - October 15, 1981

<u>Sample #</u>	<u>Description</u>	<u>Moisture Content</u> <u>(% by dry weight)</u>
1.	Shavings before hammer mill (belt not moving)	11.4%
2.	Fines after hammer mill (belt moving)	14.9%
3.	Pellets falling out of press	10.4%
4.	Pellets after cooling	9.2%

Bulk (loose density)

both samples taken as pellets after cooling

sample #1 = 34.7 pcf

sample #2 = 34.5 pcf

Note: loose density samples were poured into a 0.1 cf container

John W. Lund
Civil Engineer

MODOC LUMBER CO.
Pellet Plant Test Results

Moisture and density samples - October 16, 1981

<u>Sample #</u>	<u>Description</u>	<u>Moisture Content</u> (% by dry weight)
1.	Woodex from Burney, California	8.8%
2.	Modoc pellets from shavings w/o steam	8.6%
3.	Modoc pellets using hog fuel	8.8%

<u>Sample #</u>	<u>Bulk (loose density)</u> <u>Density in pcf</u>	<u>Additional</u> <u>Description</u>
1. Woodex	34.9 and 35.6	Many fines, dark & short pieces
2. Modoc	33.9 and 34.5	light & short pieces (1/4-3/8 in)
3. Modoc	40.4 and 40.6	dark & long pieces (1 to 2 inches)

<u>Sample #</u>	<u>Apparent (solid density)</u> <u>(toluene displacement)</u> <u>Density in pcf</u>	<u>Condition</u>
1. Woodex	82.1 81.8	oven dry 8.8% moisture
2. Modoc	83.1 84.4	oven dry 8.6% moisture
3. Modoc	85.2 85.5	oven dry 8.8% moisture

Note: an attempt was made using water displacement, however the samples either disintegrated or some particles floated.

Loose density samples were poured into a 0.1 cf container

John W. Lund
Civil Engineer

MODOC LUMBER CO.
Pellet Plant Test Results

Moisture and density samples - October 17, 1981

<u>Sample #</u>	<u>Description</u>	<u>Moisture Content</u> (% by dry weight)
1.	Woodex from Burney, California	8.8%
2.	Modoc pellets from shavings w/o steam	8.6%
3.	Modoc pellets using hog fuel	8.8%

<u>Sample #</u>	<u>Bulk (loose density)</u> <u>Density in pcf</u>	<u>Additional</u> <u>Description</u>
1. Woodex	34.9 and 35.6	Many fines, dark & short pieces
2. Modoc	33.9 and 34.5	light & short pieces (1/4-3/8 in.)
3. Modoc	40.4 and 40.6	dark & long pieces (1 to 2 inches)

<u>Sample #</u>	<u>Apparent (solid density)</u> (toluene displacement) <u>Density in pcf</u>	<u>Condition</u>
1. Woodex	82.1 81.8	oven dry 8.8% moisture
2. Modoc	83.1 84.4	oven dry 8.6% moisture
3. Modoc	85.2 85.5	oven dry 8.8% moisture

Note: an attempted was made using water displacement, however the samples either disintegrated or some particles floated.
Loose density samples were poured into a 0.1 cf container

John W. Lund
Civil Engineer

MODOC LUMBER CO.

Pellets Plant Test Results

Moisture samples - October 21, 1981

<u>Sample #</u>	<u>Description</u>	<u>Moisture Content</u> <u>(% by dry weight)</u>
1.	Shavings before hammer mill	7.6%
2.	Fines after hammer mill	9.4%
3.	Pellets falling out of press (no steam)	6.0%
4.	Pellets after cooling (no steam)	5.7%
5.	Pellets falling out of press (with steam)	10.0%
6.	Pellets after cooling (with steam)	8.4%

Note: temperature with steam (dial gauge on press) = 195° F)

John W. Lund
Civil Engineer

MODOC LUMBER CO.

Pellet Plant Test Results

Moisture samples

	<u>% by dry weight</u>
1. Taken Oct. 28 - pellets after cooling (hog fuel)	9.6%
2. Taken Nov. 4 - fines after hammer mill	11.0%
3. Taken Nov. 4 - pellets after cooling	8.3%

Note: sample of Oct. 28 was tested on Nov. 4.

Bulk (loose) density

1. Taken Oct. 28 - pellets after cooling: 16.4 PCF
2. Taken Nov. 4 - pellets after cooling: 31.0 and 31.3 PCF
3. Taken Oct. 21 - pellets after cooling: 36.9 and 38.1 PCF

Apparent (solid) density - toluene displacement

1. Taken Oct. 28 - pellets after cooling: 78.0 PCF (oven dry)
2. Taken Nov. 4 - pellets after cooling: 83.6 PCF (oven dry)
3. Taken Oct. 21 - pellets after cooling: 85.8 PCF (air dry)

Note: samples from Oct. 28 were darker and in smaller pieces
also compared to the other samples. See previous
report for moisture content of Oct. 21 samples.

John W. Lund
Civil Engineer

MODOC LUMBER CO.

Pellet Plant Test Results

Sample description

- #1 sampled on November 4, 1981 - hog fuel - dark color - 1/2-3/4 inch long
- #2 sampled on November 18, 1981 - yellow pine - light color - 1/4-1/2 inch long
- #3 sampled on November 18, 1981 - yellow pine fines (after hammer mill)

Moisture

Sample #1 = 10.9%

Sample #2 = 6.5%

Sample #3 = 10.2%

Bulk (loose) density

Sample #1 = 34.1 pcf (@ 10.9% moisture)

Sample #2 = 32.5 pcf (@ 6.5% moisture)

Apparent (solid) density - toluene displacement

Sample #1 = 86.4 pcf (oven dry)

Sample #2 = 84.4 pcf (oven dry)

John W. Lund
Civil Engineer

MODOC LUMBER CO.
Pellet Plant Test Results

Sample description

- #1 sampled on November 25, 1981 - yellow pine fines (after hammer mill)
- #2 sampled on November 25, 1981 - yellow pine pellets - 1/2" to 1" long (w/o steam)
- #3 sampled on December 2, 1981 - yellow pine fines (after hammer mill)
- #4 sampled on December 2, 1981 - yellow pine pellets (with steam) - 1/4" to 1/2" long
- #5 sampled on December 9, 1981 - yellow pine fines (after hammer mill)
- #6 sampled on December 9, 1981 - yellow pine pellets - 1/4" to 3/4" long

Moisture

- Sample #1 = 13.8%
- Sample #2 = 9.7%
- Sample #3 = 6.5%
- Sample #4 = 5.8%
- Sample #5 = 10.8%
- Sample #6 = 7.6%

Bulk (loose) density

- Sample #2 = 34.9 and 35.2 pcf
- Sample #4 = 32.0 and 32.1 pcf
- Sample #6 = 35.3 and 34.3 pcf

Apparent (solid) density - toluene displacement

- Sample #2 = 84.9 pcf
- Sample #4 = 83.6 pcf
- Sample #6 = 82.7 pcf

John W. Lund
Civil Engineer

MODOC LUMBER CO.
Pellet Plant Test Results

Moisture Content

1. Yellow pine fines - taken on December 16, 1981 (after hammer mill) = 8.9%
2. Yellow pine pellets - taken on December 16, 1981 (1/4-1/2" long with
many fines) = 8.4%

Bulk (loose) density

Yellow pine pellets = 28.4 pcf

Apparent (solid) density - toluene displacement

Yellow pine pellets = 85.0 pcf

John W. Lund
Civil Engineer

MODOC LUMBER CO.
Pellet Plant Test Results

Description

1. Yellow pine fines - taken on January 6, 1982 (after hammer mill) -
with many broken pellet pieces.
2. Yellow pine pellets - taken on January 6, 1982 (1/4-1/2" long)
3. Yellow pine fines - taken on January 13, 1982 (after hammer mill)
4. Yellow pine pellets - taken on January 13, 1982 (1/4-1/2" long)

Moisture Content

1. 7.5%
2. 5.8%
3. 11.6%
4. 5.9%

Bulk (loose density)

2. 30.0 pcf
4. 29.2 pcf

Apparent (solid) density - dry - toluene displacement

2. 83.7 pcf
4. 83.9 pcf

John W. Lund
Civil Engineer

MODOC LUMBER CO.

Pellet Plant Test Results

Description

1. Yellow pine fines - taken on January 20, 1982 (after hammer mill)
2. Yellow pine pellets - taken on January 20, 1982 (1/4 to 3/4" long)

Moisture Content

1. Yellow pine fines: 8.3% and 8.2%
2. Yellow pine pellets: 7.7%

Bulk (loose) density

2. Yellow pine pellets: 32.9 pcf

Apparent (solid) density - dry - toluene displacement

2. Yellow pine pellets: 84.5 pcf ^e

NOTE: moisture recorder at plant registered 9.6% when fines moisture sample was taken.

John W. Lund
Civil Engineer

Appendix I

GEOTHERMAL RESOURCE EXPLORATION REPORTS

EVALUATION OF THE GEOTHERMAL POTENTIAL
OF THE
MODOC LUMBER COMPANY PROPERTIES
AND
POTENTIAL WELL SITE SELECTION
KLAMATH FALLS, OREGON

for
MODOC LUMBER COMPANY, INC.
KLAMATH FALLS, OREGON

by
Murray C. Gardner
GeothermEx, Inc.
Berkeley, California

February 1981

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CONCLUSIONS

1. The probability is good that aquifers exist beneath the Modoc Lumber Company property capable of producing at least 500 gpm from depths between 1,000 to 2,000 feet.
2. The temperature gradients at the property, and consequently the depth at which temperatures will exceed 150°F, is uncertain. Well-temperature data recorded in the immediate vicinity of the property are limited to shallow depths. Both anomalously high and low gradients occur in wells to the west and northwest of the property. A significant thermal anomaly occurs northeastward in Klamath Falls and may extend beneath the property. Therefore, a risk exists in trying to obtain temperatures of 150°F or higher at depths of 1,000 to 2,000 feet.
3. Drilling on this property should be located in the northeastern part of the property, as close to the possible fault traces bordering Lake Ewauna as is practical, because there is association of thermal anomalies and faults.
4. Cost for a production hole, at \$40/foot including casing and completion to 1,500 feet, would be \$60,000. If pumps are needed to assist flow, cost will increase accordingly. A production well will probably need to be 12 inches in diameter.

INTRODUCTION

GeothermEx, Inc. was authorized in January, 1981 to perform an evaluation of the geothermal potential of the Modoc Lumber Company properties bordering Lake Ewauna near Klamath Falls, Oregon (figure 1). The purpose of the evaluation was principally to analyze the potential of the properties to support process heat requirements for densification of plant waste materials to solid fuel pellets. This assignment was directed by Eliot Allen & Associates, principal consultants to Modoc Lumber Company, and ordered by Mr. Kent Schmidt of the Wood Energy Products program.

Location

Modoc Lumber Company properties are comprised of about 150 acres distributed principally around the shores of Lake Ewauna. There are 3 parcels. The first is comprised of 40 acres along the north and east shores of the Lake, and extending into Klamath Falls City. This is the area of principal interest. The other parcels are on the western shore of the Lake and are both more distant from proven geothermal resources and from areas of potential use. A pipeline with prohibitive costs would be required to move thermal fluids from the western parcels to the use area.

Preface

Modoc Lumber Co. has already accomplished several months of research and development activities for the solid fuel pellets program, with financial assistance from the U. S. Department of Energy. Geothermal energy may or may not be utilized, depending upon results of this feasibility study and exploration. The concept questioned was whether to (1) drill 1 one-thousand-five-hundred (1,500) foot depth hole, and attempt to produce about 500 to 1,000 gallons of water per minute (gpm) at temperatures of at least 150°F; (2) drill several five hundred (500) feet depth holes to examine temperature gradients; or (3) to abandon plans to use geothermal energy to supplement fossil energy.

Methods and Scope of Work

GeothermEx was requested to (a) review existing literature and documents about geology, hydrology, well temperatures and production; (b) visit the Modoc Lumber Company property to make a reconnaissance of

EXPLANATION OF GEOLOGIC SYMBOLS USED IN FIGURE 1.

- Formation contact, dashed where approximately located
- Fault, dashed where uncertain, dotted where projected beneath alluvium. Ball shows direction of movement. Yellow indicates possible faults or fault zones interpreted from gravity and topography.
- Attitude of bedding. Figure shows amount of dip

MAP UNITS

Q1

Alluvium, fluvial and lacustrine deposits

Ts
Tb

Ts = Pliocene lacustrine sedimentary rocks (claystone, siltstone, volcanic sandstone, basalt tuff, diatomite)
Tb = basalt flows, including some cinders and breccia around eruptive centers

Tob

Older basalt, including breccias, cinders, minor palagonite tuff and thin interflow sedimentary rock

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the geology and hydrology; and (c) site a test hole or holes in the event it appeared valid to assume the existence of adequate geothermal fluids in the prospect area.

The principal result of the investigation was to be a concise report. This report fulfills the scope of work of the feasibility study. During the months of January and February, 1981, literature from public and private sources was collected and reviewed. A visit was made to Klamath Falls and discussions held with principals of Modoc Lumber Company and Eliot Allen & Associates, and a reconnaissance was made of the vicinity of the plant site. Data from wells was collected by Eliot Allen & Associates, as well as directly by GeothermEx from city and state agencies.

One of the proposed parts of the program was to use well information to construct a detailed geologic cross-section of the vicinity of the Modoc Lumber property. There is insufficient subsurface data to permit this undertaking with any significant detail. The structure of the area has been analyzed as far as possible to help site an exploration well.

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GEOLOGIC SETTING

The area studied is at the southwestern margin of Klamath Falls City, and occupies the valley floor of the Klamath River between the Upper and Lower Klamath Lake depressions. This valley is a fault-bounded basin in the Klamath graben complex. This regional zone of en echelon fault-bounded ridges and valleys extends for at least 90 miles, from the Medicine Lake Highland volcanic center, California, on the south to the vicinity of Crater Lake, Oregon, on the north. From west to east the graben complex extends from Lake of the Woods, Oregon to the Sprague River Valley, Oregon. The Klamath Falls geothermal field is located along the east flank of the axial part of the Klamath graben.

Structure

The Klamath Basin is broken into numerous ridges (horsts) and valleys (grabens) by northwest-trending normal faults (figure 1). In the area northwest of the site the faults are closely coincident with steep topographic escarpments. At and southward of the site, the fault topography has been reduced by erosion and the landform has been covered by lacustrine and fluvial sediments. However, it is believed that the fault pattern persists beneath the younger deposits and that Miller Hill, as well as the small hill in Section 9, T. 39 S., R. 9 E., the low scarp along the west side of Lake Ewauna and the hills such as Ewauna Heights are fault-bounded. These faults are likely to be similar to those exposed in many uplifts in the Klamath Basin. Gravity data are insufficient to define them and the city culture obscures surface evidences. Exposures in many parts of the Klamath graben complex indicate that fault planes dip at 60° to 80°. It is assumed that any faults in the project area would follow this geometry.

Reconnaissance gravity data generally confirm a northwest structural grain of the area (Sammel, 1976). The data also indicate that important northeast-trending faults may be present. The property lies immediately southward along the trends of the projection of probable northwestward-trending faults north of Lake Ewauna, and near a possible northeastward trending structure indicated by the gravity data beneath the Klamath River.

Some of the faults in the region act as conduits for deep-circulating water, which rise surfaceward after heating at depth, and may spread laterally into shallow porous rock layers. The narrow, linear, northwest strike of the thermal anomalies at Klamath Falls,

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Klamath Hills, and Miller Hill support the close association of elevated groundwater temperatures with faulting.

Historical Geology and Stratigraphy

The oldest rocks which can be projected beneath the area with reasonable certainty are eastward-dipping Oligocene and Miocene volcanic and volcanoclastic sedimentary rocks exposed along the western side of the Cascade Range. The surface outcrop of these rocks closest to the project area occurs about 20 miles westward, in the Klamath River Canyon. The sequence of the rocks exposed there is estimated to be from 12,000 to 20,000 feet thick (Hammond, written communication, 1975).

Rocks belonging to this suite of Western Cascades rocks also appear to have been penetrated in the Thermal Power O'Connor Ranch No. 1 deep geothermal test well (40/9-35 ca), drilled in the Klamath Hills.

A variety of rock types are present in this assemblage, including abundant basalt flows; andesite flows, brecciated pyroclastics; and light colored, more acidic tuffs. Tuffaceous sedimentary rocks ranging from claystone to conglomerate are interbedded with the volcanic rocks. Little is known concerning the reservoir potential in these rocks, because no wells penetrate them. However, they are significant to geothermal prospecting, because deep tests drilled in search of high temperature fluids are likely to encounter them.

About 4 to 5 million years ago, following the deposition of the Western Cascades volcanic rocks, a period of widespread eruptions of basalts and basaltic andesites began. Extensive basalt flows were erupted to form tablelands and many of the older volcanic edifices of the High Cascades were built. Extensional faulting also began during this period.

Larger lakes formed in the areas of impeded drainage caused by volcanic and fault activity. The deposits of these lakes consist of diatomite, siltstone, claystone, basaltic tuff and sandstone, altered to palagonite. These deposits interfinger with lavas from contemporaneous eruptive centers.

Late in this period, faulting intensified, resulting in the development of the downdropped graben valleys and uplifted horst mountain ridges which characterize the present topography of the region. The lakes occupying the valleys continue to deposit clay, silt, tuff, peat and diatomite to the present time in many areas.

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Volcanism also continued at a few localities such as Mount Mazama and Brown Mountain in the High Cascades and at the Modoc Lava Beds and Medicine Lake Highland until a few thousand years ago.

The history of this Pliocene to Holocene period is of special importance to geothermal prospecting. The lava flows of the early part of the period form the most productive shallow ground water reservoirs in the area. As such they also appear to produce most of the thermal water encountered in the region by this shallow drilling. The overlying lake sediments form impervious cap rocks over these reservoirs in the graben areas. The faults originating during this period provide fracture zones along which ground waters may circulate to great depths, be heated, rise convectively and spread out into the shallow aquifers. Calculations by McIntyre and Gardner (1980) and Sammel (1978) indicate a base reservoir temperature of about 265°F.

A number of localities in the Klamath graben complex contain thermal springs and wells. The most productive of these is in the City of Klamath Falls, where active development of shallow zones of water ranging from 135°F to more than 200°F has been going on for many years. Other areas with less-well-defined potential occur at Miller Hill, the north and west sides of Stuckel Mountain, Olene Gap, Eagle Point in Upper Klamath Lake, Yonna and Langell Valleys and along the west flank of Klamath Hills (Peterson and McIntyre, 1970).

The stratigraphic section illustrated in figure 1 and likely to be present beneath the site is summarized as follows.

Surface Deposits (Q1). These materials consist of silt, sand and clay in the flood plain of the Klamath River and flats around Lake Ewauna, where they may be as much as 100 feet thick. Elsewhere, they are less than 10 feet thick. Close to and surrounding basalt hills, the unit may include coarse basaltic scree. At the site, thick silt, sand and clay is likely to occur to below 100 feet depth.

Sedimentary rock (Ts) and Interbedded Basalt (Tb). Sediments (Ts) of the geologic section consists of lacustrine siltstone, claystone, palagonitic tuff, tuffaceous sandstone and diatomite in the areas east and south of the Klamath River. In one well (39/9-4aa), these materials are 1,040 feet thick. These rocks generally do not contain porous beds capable of large sustained water production. The upper part of the sedimentary section has been removed by erosion to the west of the river and the lower part, at least 250 feet thick, is interbedded with basalt flows, cinders and breccia. The origin of the volcanic rocks is apparently from small local eruptions. In the vicinity of the eruption vents, the rocks may be entirely basalt. Where

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basalt (Tb) predominates, it is not possible to separate this rock unit from the underlying formation (Tob), which is also composed of basalt flows. Sedimentary rocks are exposed north of the site, and their thickness is uncertain.

Older Basalt (Tob). The oldest rocks observed and mapped in this part of the basin consist of a sequence of basalt flows, flow breccias with thin interflow cinder zones, and tuff beds. The total rock unit may be more than 2,000 feet thick. The geologic sections mapped in Plum Hills and Hogback Mountain, northeast of Klamath Falls, are thought to be typical materials of this period. The boundary between (Tob) and (Tb) basalts is difficult to establish. The basalts of both units contain the important water-bearing zones.

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HYDROLOGY

A model for ground water circulation in the Klamath Basin has been proposed by Illian (1970). Local, regional and intermediate ground water circulation regimes are illustrated in this model. The characteristics of the local systems are the short travel times and shallow depths of circulation between the recharge and discharge areas. Low water temperatures and low total dissolved solids concentrations are characteristic of this system.

By contrast, the regional system receives recharge from the Cascade Range. On the east side of the basin, infiltration through porous lava flows into fault zones takes place. This water may descend into the fault zones to depths greater than 10,000 feet and move laterally for long distances. The characteristics of water in this system are the long time and distance it remains in transit, its relatively high temperature and concentration of total dissolved solids. The conditions in this regional flow system appear to be adequate to account for the temperatures and compositions of waters found in the Klamath graben complex, without requiring an igneous heat source.

The intermediate flow system falls between the two already described. However, some waters appearing to belong to the intermediate system may actually be the result of mixing of local, shallow ground water with water rising from the regional source along faults.

No single continuous aquifer has been defined. The porous intervals are probably not continuous over long distances; this is true even for basalts. However, they may communicate with one another through fracture systems. Productivity from the basalt section varies considerably from well to well, depending on the porosity in individual zones and the number of such zones intercepted. From 20 to 2,000 gallons per minute have been produced in different wells. From the data available in the region, the probability is good that fluid production of more than 500 gpm can be obtained from a well drilled to depths of 1,000 to 2,000 feet, the depths at which temperatures of interest occur.

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TEMPERATURE GRADIENTS

Several interrelated factors influence the temperature gradients encountered in wells. Among these are the mode of heat transfer, the varying thermal conductivities of different rock types, and the heat flow. Two types of heat transfer may occur. Of these, conductive heat flow takes place in non-permeable rocks. By contrast, convective transfer takes place by convective circulation of fluids through porous and permeable rocks. The thermal conductivities of various rock types are inherent properties of these rocks. Certain fine-grained, non-permeable rocks such as diatomite, clay and silt have low thermal conductivities, while crystalline rocks such as lavas have higher conductivities for any given heat flow. Heat flow itself is calculated, being the product of the observed average gradient in gradient holes, wells and mine shafts, multiplied by the measured thermal conductivity of the rock. Therefore, heat flow varies depending on whether the site of measurement is typical for an area or is influenced by local geological or hydrological conditions.

The essential factors which determine the success of geothermal drilling operations may be found at the site. The factors are: (1) presence of porous reservoir rocks capable of sustained production of fluids at the required rates, (2) occurrence of temperatures required for the projected uses, and (3) factors (1) and (2) at depths from which the fluids can be exploited economically.

The distribution of thermal gradient anomalies in the Klamath Falls areas is shown in figure 2. These are areas outlined from existing well data, in which gradients greater than 6.5°F per 100 feet occur and in which a temperature of 160°F or higher is likely to be encountered at a depth of 2,000 feet (Lund, 1978). The Modoc Lumber Company site is west of the present limits of production and use in the Klamath Falls City geothermal field. The site is northward from the northwestern end of a narrow anomaly extending through Sections 9 and 15. The site is within the area where it has been speculated (Lund, 1978) that there is a greater than average potential for hot-water from 120°F to 212°F at depths of 1,500 to 3,000 feet. Several shallow wells in the area provide temperature gradients and water flow at temperatures that support Lund's estimation.

To the northwest of the Klamath River, wells with gradients both above and below 6.5°F per 100 feet have been reported, but no pattern in their distribution is apparent. No well data are available from the east half of Section 5, or in parts of Section 4. Four wells are present in the west half of Section 5, ranging in depth from 185

FIGURE 2. Outline of thermal anomalies in the Klamath Falls area (modified from Lund, 1978).

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to 308 feet. One hole (39/9-5cc), along a projection of the anomaly in Sections 9 and 15, recorded a temperature of 65°F at a depth of 247 feet, with an average gradient of 6.8°F per 100 feet. The gradients in the other three holes, which are also along the northwestern projection of the anomaly in Sections 9 and 15, range from 2.6°F to 3.8°F per 100 feet.

The Modoc Lumber Company property is generally outside of the areas studied and reported upon by Lund (1978). On most maps in Lund's report, the property is southwest of the termination of temperature gradient contour lines and other factual and interpretive guides.

Map No. 8 of Lund (1978), which shows artesian and pumped wells, does show an area with four thermal wells between 4th Street and Lake Ewauna which are used for heat pumps. The closest 2 are near Pine and Klamath Avenues.

There is little question that the maximum well temperatures fall off rapidly toward Lake Ewauna from the central part of the hot well area. Temperatures of 40°C (145°F) have been observed within 1,000 feet of the Modoc Lumber Company property.

Temperature information was obtained from public and private sources for several wells located within the vicinity of Modoc Lumber Company property. In nearly all cases, gradients calculated from the maximum temperatures of water in the wells were greater than 6°F/100 feet. This permits speculation that aquifer temperatures may be higher than 150°F in a hole drilled to 1,500 feet depth. Local well information includes:

1. Ganong - 323 Main Street
Temperature - 64°F
Static Water Level - 16 feet
Total Depth - 155 feet

This well increased about 14°F in 155 feet or about 9°F/100 feet. It could be projected to a temperature of 180°F at 1,400 feet depth, with the above-mentioned cautions.

The well did intercept beds of basalt from 28 to 148 feet depth, according to the driller's logs.

2. Molatore - 626 South 7th Street
Temperature - 74°F
Static Water Level - 7 inches
Total Depth - 378 feet

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This well increased about 24°F in 378 feet or about 6-1/2°F/100 feet. It could be projected to a temperature of 130°F at 1,400 feet depth again with suitable cautions. The well bottomed in 13 feet of "black broken basalt." It is not certain whether the well entered an isothermal regime.

3. Molatore - 100 Main
Temperature - 69°F
Total Depth - 307 feet
Static Water Level - 76 feet. Water encountered at 144 feet.

This well increased about 19°F in 307 feet or about 6°F/100 feet. This is approximately the same as No. 2, the "other" Molatore well. The well bottomed in 30 feet of basalt.

4. Consumer Heating/Klamath Heating Co. - 38-9-321(1)
Temperature - 72°F
Static Water Level - ?
Total Depth - 263 feet

The well increased about 22°F in 263 feet depth or about 8°F/100 feet. This gradient would project to about 170°F at 1,400 feet. Lithologies were not found.

5. Oregon Water Corp. City Well #9 - 5th & Elm Streets
Temperature - 75°F
Static Water Level - ?
Total Depth - 845 feet

The well increased 25°F in 845 feet depth, for a gradient of about 3°F/100 feet. This is basically a cold water well. The well entered basalt aquifers at about 400 feet and is possibly isothermal below that depth. Basalts persist until about 733 feet, when stick shales occur.

An abandoned well at the entrance to the Modoc Lumber Company administrative headquarters was opened, flowed and measured. The history and depth of the well are indefinite.

From these data it appears that a drill hole at the site would have a temperature gradient of more than 6°F per hundred feet and may intercept water between 150° and 200°F at depths between 1,000 and 2,000 feet. There are uncertainties and risks in this, reflecting the

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uncertainties of (a) temperature gradient at the site, and (b) depth to a thermal aquifer. For example, if a thermal aquifer were encountered at 800 feet, at a gradient of 6°F per hundred feet, temperature would be 98°F. If an aquifer were found at 1,500 feet, and the gradient were 6°F per hundred feet, the temperature would be 140°F.

The ideal situation would be one in which formations with low permeability are penetrated by a drill hole to depths of about 1,400 feet. The low permeability rocks--non-fractured siltstones, tuffaceous sediments and so forth--would permit the conductive temperature gradient to continue and increase. Then, below 1,400 feet depth, a high permeability unit such as fractured basalt would be required to provide adequate water flow or circulation around a heat exchanger. Whenever a high permeability unit is penetrated, it is expected that the temperature will become isothermal or nearly so; unless a succession of low and high permeability units were penetrated, this would lead to step-ups in temperature. The records from the majority of Klamath Falls hot wells indicate that a single cell is to be expected once the permeable formation is reached. Using an average annual temperature of 50°F for a base, if there were a minimum temperature gradient of 7°F/100 feet, a temperature of 150°F would occur at 1,400 feet depth. Of course, there may be a sudden and significant increase when a hot aquifer is encountered, but this event is entirely fortuitous and speculative now.

DRILLING SITE SELECTION

On figure 3, areas are recommended for the geothermal well site. A final location would depend upon (a) site accessibility and (b) environmental or land-use factors. These could only be resolved after a final field inspection.

Within the geothermal well site area, it is reasonable to suppose that drilling to approximately 1,500 feet will result in intersection of fault zones, and in production of hot water from shattered volcanic rocks in and adjacent to the faults. Exact quantities and temperatures cannot be predicted. However, 150°F (or slightly higher) seems reasonable near the fault zones on the basis of temperature gradients in shallow wells and on regional considerations of the geothermal regime.

If yield from the first well is inadequate, it may be necessary to construct a second well. If the decision can be taken at once to do so, before the rig has been released, significant savings in rig costs for mobilization and demobilization can be achieved. This would presuppose that funding for 2 wells could be prearranged, even if only one were ever to be drilled.

The well should be drilled to design specifications to produce the fluid volume required. If upward of 700 gpm are sought, then a well 6-inches in diameter will likely be undersized. However, a 6-inch exploration well, into which temperature and air lift test tubing (ex. 2-7/8-inch) can be set, through a packer to isolate thermal from cold aquifers, can be drilled within the budget. A 6-inch well can be drilled to 200 feet depth at 9 to 12 inch diameter, 7-inch casing run and cemented and the hole diameter then reduced to 6 inches. It may not be necessary to case the hole to 200 feet depth, depending upon state regulations and conditions of the hole. These holes are commonly drilled for less than \$25,000, on a per hour rather than a per foot drilling contract. The well would not be capable of production beyond 100 to 150 gpm. The casing could be removed, and the hole reamed and fully developed.

A production size well for 700+ gpm would require a different program. A general example is:

26-inch diameter to about 100 foot depth, with 20 to 22-inch conductor casing set.

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17-1/2-inch diameter to the production zone, with 12-3/4 to 13-3/8-inch casing set.

12-1/2-inch diameter hole through the production zone, completed barefoot or with 8-5/8-inch slotted liner, possibly gravel packed. This hole design would quite possibly cost more than \$60,000.

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DRILLING REPORT

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PRELIMINARY MUD LOG ON MODOC LUMBER CO. WELL

<u>Depth in Feet</u>	<u>Description</u>
0 - 30	<u>Gravel, sand and silt</u> - unstratified basin sediments, less than 5 % clay.
40 -60	<u>Pebbly clay</u> - grayish olive (10Y4/2); poorly sorted, non calcareous lake sediments.
70- 160	<u>Sandy clay</u> - olive gray (5Y3/2); poorly sorted, some black mudstone and siltstone chips in the clay, non calcareous lake sediments.
160 - 220	<u>Shale</u> -olive black (5Y2/1); very fine grained, well sorted lake sediments of mafic igneous parent rock.
220 - 311	<u>Shale</u> - olive gray (5Y4/1); very fine grained, moderately sorted. Some aphanitic basalt and minor amounts of light gray to brown chalcedony occurring as vesicle fillings in basalt.
320 - 370	<u>Basalt</u> - dark gray (N3); aphanitic, subhedral to anhedral plagioclase (55%), hornblende and pyroxene (30%), glass (10%), remainder opaques; hematite, magnetite. Chalcedony as vesicle fillings and minor amounts of tuff altering to clay.
380	<u>Clay</u> - medium light gray (N6); very fine grained no bedding noted. 75% of material is of mafic igneous origin, remainder is basalt fragments similar to sample 320-370 above.
390 -410	<u>Basalt</u> - medium dark gray (N4); same as sample 320-370 above with white tuffaceous clays in minor amounts.
410 - 412	<u>Shale</u> - medium dark gray (N4); <u>Basalt</u> - grayish black (N2); both phaneritic and aphanitic basalt in sample. Aphanitic basalt is vesicular, similar to above.
420 - 425	<u>Basalt</u> - medium gray (N5); fine grained, phaneritic with pyrite lining some vesicles. Plagioclase in basalt is altering to chlorite. Minor amounts of volcanic siltstone and tuffaceous clay also in sample.
425 - 470	<u>Tuffaceous clay</u> - light gray (N7) clay is altered from tuff and volcanic glass. Possible bedding or alignment of grains as in waterlain tuff, but alteration obscured evidence. Only minor altered basalt (less than 10% of sample).
474 - 480	<u>Basalt</u> - medium gray (N5); vesicular with chalcedony partially filling vesicles. Composition similar to basalt above. 10% of sample is light gray tuffaceous clay.

- 490 - 540 Tuffaceous clay - very light gray (N6); similar to composition of sample 425-470. This sample contains vesicular basalt in amounts less than 10% of sample.
- 545 Tuffaceous clay - medium light gray (N6); composition similar to sample 425-470. But this sample contains 15% fine grained volcanic sandstone and minor amounts of light gray to white chert.
- 550 Chert - brownish gray (5YR4/1); to very light gray (N8); 98% of sample is chert with remainder altered basalt and tuff.
- 551 - 560 Basalt - medium gray (N5); 70% of sample is aphanitic vesicular basalt with altered plagioclase and glass yielding a gray-green chloritic clay matrix. Remainder of sample is equal amounts of light gray tuffaceous shale and chalcedony.
- 570 Volcanic Sandstone - medium gray (N5); fine grained, rounded, sandstone and siltstone with some mud chips and chert fragments.
- 580 - 600 Basalt - medium gray (N5); some phaneritic, fine grained and some altered aphanitic basalt; both are vesicular with a blue gray, chalcedony with a drusy texture lining the vesicles. Sample also contains less than 10% volcanic siltstone and tuffaceous clay.
- 600 - 620 Basalt - medium dark gray (N4); aphanitic vesicular basalt with chalcedony lining vesicles. Sample also contains less than 5% tuffaceous clay.
- 620 - 640 Basalt - similar to 600 - 620 sample above. But a very thinly laminated volcanic siltstone occurs with the tuffaceous clay in amounts less than 15%.

Conclusions: Some alteration of the basalt was first noticed at the 410 -420 foot level. This seems to be the result of low grade hydrothermal reactions. The occurrence of sulfides as vesicle fillings in the basalt could also be interpreted as dentritial in origin. Also at this level was the first appearance of wide spread alteration of the plagioclase to chloritic clay. At the 530 foot level the first appearance of volcanic sandstone overlying a chert layer at 550 feet and highly altered vesicular basalt at 560 feet occurs. The sandstone with chert also reoccurs at 570 feet and a minor amount at 630 feet. The basalt between 530 and 630 feet appears to have undergone some alteration either due to low grade hydrothermal or descending meteoric waters. The basalt at the 640 feet level show little if any alteration.

Dennis Glover
August 19, 1981

MUD LOGGING REPORT
MODOC LUMBER CO. GEOTHERMAL WELL
650' to 1110' LEVEL

650' BASALT- Medium gray (N5), 85% of sample is aphanitic basalt with very little alteration, 15% is waterlain light gray to white tuff or tuffaceous sediments.

660'-679' BASALT- Medium dark gray (N4), 80% aphanitic basalt with alteration increasing with depth, remainder is tuffaceous sediments, ranging from fine grained sand to clay in size.

679' BASALT- Dark gray (N3), highly altered vesicular basalt with secondary minerals lining vesicles.

690' BASALT- (N3), 70% slightly altered and fractured, remainder is clay.

692'-706' SILTSTONE/SHALE- Medium gray (N5), 70% volcanic siltstone composed of 35% lithic fragments, 30% mafics and hematite, magnetite, 15% pumice frags. , 5% Qz.; remainder is shale and clay.

710-740' SILTSTONE/SHALE- Medium light gray (N6), tuffaceous siltstone 85%, remainder is shale with minor amounts of aphanitic basalt, slightly altered.

750-770' SILTSTONE- All tuffaceous siltstone, possibly graded, remainder is shale with some basalt at 770'.

780-830' SILTSTONE- 80% Tuffaceous siltstone with alteration as secondary minerals lining pore spaces, 15% shale, 5% altered basalt.

840-870' SILTSTONE/CLAY- 50 to 60% tuffaceous siltstone with altered plagioclase, remainder is clay with some very minor slightly altered basalt

874-900' BASALT- Medium dark gray (N4), 80 to 90% unaltered
aphanitic basalt interlayered with white to gray tuff

910' BASALT- Dark gray (N3), same as 890' above.

914' BASALT-Grayish red (10R4/2) highly vesicular with oxidized
hematite and magnetite.

918' CLAY- Brownish gray (5YR4/1), 55% silt/clay, 20% tuff,
25% basalt; Fe oxide and alteration.

920' BASALT/CINDERS- Light brownish gray(5YR6/1), 60% altered
basalt with Fe oxide, 40% cinders gone to clay.

930-940' BASALT/TUFF- Basalt varies, some fractured and highly
altered with the rest only slightly altered, vesicular,
approx. 40-50%; Gray tuff shows some oxidation of the mafics
but this is minor, approx. 30%; remainder of sample is
gray clay with minor (5%) white tuffaceous clay.

941' BASALT- Medium gray (N5), 50% oxidized and chloritized
basalt; 40% gray tuff; 10% clay.

949' CLAY- 80% gray clay with sub-angular to sub-rounded iron
rich fragments; remainder is slightly altered basalt with
some minor white tuff.

950-970' BASALT- 80-90% totally oxidized and chloritized dark
gray (N4), vesicular basalt; remainder is gray and white
tuff with Fe oxide.

970' SILTSTONE- 80% volcanic tuffaceous siltstone; 15% tuffaceous
clay; 5% basalt; all iron rich.

980-1020' CLAY/SILT- Dark gray(N3), 70% tuffaceous clay and silt
10-15% white tuff; 5-10% basalt.

1020-1032' Similar to 980' above but 65% clay with some rounded
siltstone pebbles and cinder fragments.

- 1032' RED CLAY- Grayish red (5R4/2), cinders and gray tuff with iron oxide.
- 1040' Same as 1032' above with only alteration in pore spaces of tuff.
- 1050' CINDERS- Dark reddish brown (10R3/4), pore spaces and vugs filled with secondary minerals including minor calcite.
- 1053' RED ASH- Same as 1040' above but minor (<5%) altered basalt.
- 1059' BASALT- Brownish gray (5YR4/1), 50% aphanitic, slightly altered basalt; 25% red cinders; 20% gray tuffaceous siltstone; 5% clay.
- 1060' Same as 1059' above but some minor white tuff included.
- 1060' #2 Same as 1053' above.
- 1069' BASALT- Medium dark gray (N4), similar to 1059' above.
- 1070' BASALT- 90% aphanitic, unaltered basalt; 5% cinders; 5% altered basalt
- 1075' BASALT- 80% unaltered basalt; 20% gray tuffaceous siltstone.
- 1080' BASALT- 70% basalt; 15% gray tuff; 15% waterlain tuff, fissile with biotite on bedding planes.
- 1090' Same as 1080' above but, 70% basalt; 20% white tuff; 10% cinders and gray tuff.
- 1100' Same as 1090' above.
- 1110' Same as 1090' above, all showing very little alteration in basalt or tuff

Investigator
Dennis Glover

MUDLOG REPORT

MODOC LUMBER CO.

GEOHERMAL WELL 1110' to 2070'

- 1110'-1130' BASALT- Medium gray (N5), 80-85% aphanitic, non-vesicular basalt; 15-20% white to light gray tuff; both show very little alteration.
- 1130'-1155' BASALT- Medium dark gray (N4); 90% vesicular basalt with natrolite and cryptocrystalline quartz occurring as vug and fracture fillings; 10% tuff with secondary pyrite as pore space filling.
- 1155'-1170' BASALT- Medium gray (N5); 100% highly altered, chloritized basalt.
- 1170'-1176' BASALT- Medium dark gray (N4); totally altered basalt, chlorite and clay along with granular fragments.
- 1176'-1180' TUFFACEOUS SILTSTONE- Medium gray (N5); 15% rock frags., 15% mafics & opaques, 70% SiO₂; minor clay.
- 1180'-1190' SHALE- 95% shale/siltstone; 5% white tuff.
- 1190'-1210' SILTSTONE/SHALE- 90% Sltst./Sh.; 5% white tuff; 5% slightly altered, vesicular basalt with chlorite as symmetrical bands partially filling cavities.
- 1210'-1215' SANDSTONE/SILTSTONE- 50% Sst., very fine to fine grained graywacke; 45% Sltst.; remainder is basalt and tuff.
- 1215'-1240' SANDSTONE- very fine grained, round to sub-angular grains, composed of 50% Qz & Fsp; 20% mafics, opaques; 20% rock frags.; 10% glass in a clay matrix.
- 1240'-1270' SILTSTONE/MUDSTONE- 60% siltst & fine grained sst; 40% mudstone & claystone with minor tuff; tuff appears to be waterlain, evidenced by thin laminae, and increases to 15% of sample at 1260'.

- 1270'-1320' SILTSTONE/SANDSTONE- 80% sltst; 15% sst; 5% tuff;
sandstone is very fine grained, porous with clay as pore filling;
tuff is white, waterlain and increases to 20% at 1280'.
- 1320'-1350' Same as 1320' above but with minor amounts of basalt.
- 1350'-1370' SILTSTONE- 55% gray sltst; 25% white, waterlain tuff;
10% aphanitic basalt, only slightly altered.
- 1370'-1390' SILTSTONE- 65% sltst; 20% tuff; 15% fine grained sst;
also minor basalt and symmetrical bands of clay lining pores.
- 1390'-1430' SILTSTONE- 70% sltst; 15% tuff; 15% basalt; similar to
1360' above but tuff is opalized and basalt is altered (chloritized).
- 1430'-1440' BASALT- Medium dark gray (N4); 50% altered basalt; 25%
sltst; 15% white tuff; 5% chert.
- 1440'-1450' SILTSTONE- 50% sltst; 30% altered basalt; 15% tuff;
5% chert.
- 1450'-1460' SILTSTONE- 55% sltst; 20% altered basalt; 20% tuff.
- 1460'-1508' SILTSTONE- 70% epiclastic volcanic sltst; 15% tuff;
15% basalt; The siltstone of this member appears to be reworked
by water and is possibly a graded deposit with basalt as the
major rock fragments in the silt/clay matrix.
- 1508'-1520' SHALE- Medium gray (N5); Very thinly bedded (poor
evidence) possibly massive or blocky mudstone with minor amounts
of basalt and tuff (altered).
- 1520'-1580' SHALE- Medium light gray (N6); Similar to 1508' above
with very minor amounts of basalt and tuff.
- 1580'-1590' SHALE- Medium gray (N5); Same as 1508' above but could
be termed argillite due to better induration.
- 1590'-1600' SHALE- Same as 1580' above but basalt and tuff have
increased to greater than 10% each.

- 1600'-1640' SHALE- Medium dark gray (N4); Similar to 1580' above but basalt has increased to greater than 30% and waterlain tuff to 10%.
- 1640'-1850' SILTSTONE- Medium light gray (N6); Water deposited tuffaceous sediments, total thickness based on sample taken at 1640 foot level.
- 1850'-1900' SHALE- Light olive gray (5Y6/1); Well indurated clay and silt size particles along with minor basalt and tuff (less than 5%); Samples also show minor amounts of secondary pyrite probably deposited in the tuff and small veinlets of injected quartz.
- 1900'-1912' BASALT- Medium dark gray (N4); 60% altered aphanitic basalt; 40% dark to light gray shale; Also noted are secondary quartz veinlets and pyrite, and minor amounts of tuff.
- 1912'-1920' BASALT- 70% slightly altered aphanitic basalt; 30% argillized shale plus minor tuff.
- 1920'-1930' BASALT- 85% moderately altered basalt; 15% siltst; minor dark clay.
- 1930'-1950' BASALT- 75% highly altered; 25% shale, thinly laminated, and graded; minor tuff.
- 1950'-1960' BASALT- Brownish gray (5YR4/1); 90% moderately altered basalt; less than 10% red cinders, plus minor tuff.
- 1960'-1990' BASALT- Medium dark gray (N4); Hydrothermally altered basalt with chloritized plagioclase.
- 1990'-2000' BASALT- 90% altered basalt; 10% siltst; minor tuff.
- 2000'-2011' BASALT- 95% totally altered basalt and clay.

2011'-2020' BASALT- Varying degrees of alteration possibly due to fracturing, minor clay as end product of alteration, no tuff.

2020'-2030' BASALT- Same as 2011' above but majority is highly altered.

2030'-2040' BASALT- Same as 2020' above but with minor tuff.

2040'-2060' BASALT- Similar to 2020' above but all basalt is altered and tuff increases to 5% of sample.

2060-2070' BASALT- Majority of basalt in sample shows only slight alteration.

Investigated by
Dennis Glover, Geologist

E.E. STOREY & SON WELL DRILLING, INC

3847 HOPE STREET - KLAMATH FALLS, OREGON 97601
503/884-3990 or 503/882-1152
CONTRACTOR'S LICENSES - ORE. 74 and 601

MODOC LUMBER COMPANY

TEST #ONE
8" BOWLS SET AT 200'

SEPTEMBER 15, 16, 1981

WATER FLOWING OVER CASING AT APPROXIMATELY 10 GPM AT START

<u>TIME</u>	<u>TEMP.F.</u>	<u>WATER QUALITY</u>	<u>PUMPING LEVEL</u>	<u>GPM</u>	<u>INCHES</u>
10:55 A.M.	78 deg.	Very muddy	144'	300	17"
11:15	72	Clearing		300	12"
11:30	74	Clearing some	175'	375	18"
11:45	73	Clearing	194'	325	12½"
12:00 Noon Surge	72	Clearing	192'	300	12"
12:30 P.M. Surge	74	Clearing	195+	275	11"
1:00	74	Clear	195+	275	11"
1:30	74	Colored	195+	275	11"
2:00	74	Clearing	195+	260	9½"
2:30	74	Clearing	195+	260	9½"
3:00	74	Clear	195+	260	9½"
3:30 Surged 4 times	74	Clear	195+	260	9½"
4:00	74	Clear	195+	260	9½"
4:30 Surged 3 times	74	Muddy	195+	300	12"
5:00	74	Clear	195+	170	4"
6:00 Surged, muddied	73	Clear	111	155	3½"
6:06 Shut down,					
6:35 broken oil line					
7:00	73	Clear	195+	300	12"
8:00	73	Clear	195+	275	10"
9:00 Surged 15 min.	73	Cloudy	195+	275	10"
10:00	73	Clear	195+	275	10"
11:00 Surged	73	Clear	155	215	6"
12:00 Midnight	74	Clear	195	275	10"
1:00 A.M.	74	Clear	195	275	10"
2:00	74	Clear	195	275	10"
3:00 Surged	74	Clear	195	275	10"
4:00	74	Clear	195	275	10"
5:00	74	Clear	195	275	10"
6:00 Surged	74	Muddy and clear	195	275	10"
7:00	74	Clear	195	275	10"
8:00	74	Clear	195+	275	10"
9:00 A.M. FINAL	74	Clear	195+	275	10"

(All pumping levels measured from top of 12" surface casing)

WEEKLY REPORT
MODOC GEOTHERMAL WELL DRILLING

Week of: July 26 - August 1, 1981

The contractor (EE Storey & Son) had two mud pits excavated on the southwest corner of the vacant lot. The two pits were approximately 15 feet by 30 feet by 6 foot deep. A fence was erected around the pits for safety. Two flat bed trailers with equipment, mud pumps, and a rotary drilling rig were moved onto the site. Drilling has not been started.

John W. Lund
Civil Engineer

Handwritten: 10-3 Kent

MODOC LUMBER COMPANY
GEOTHERMAL WELL DRILLING PROJECT

Progress report for week of August 2-8, 1981

Began drilling with 17-1/2 inch diameter bit. Drilled to a depth of 317 feet over a three-day period. The last seven feet was in a competent formation (black shale) in which the surface casing could be set. Received variance from the State Watermaster to use 1/4 inch wall casing instead of 3/8 inch (the later is required for casing deeper than 250 feet). The Contractor was given permissssion to set the surface casing in the black shale formation.

Picked up 320 feet of 12-inch diameter, 1/4 inch thick casing (ASTM A53-B) from Heaton Steel. Placed and welded 320 feet of casing. Had to drive the casing the last two feet to set it on the bottom of the hole. Cut off the top three feet of casing. Installed 300 feet of 1-1/2 inch diameter PVC between casing and hole for grout placement. Placed 375 sacks of cement grout. The excess grout was probably due to a large cavity (lost circulation zone).

Dennis Glover, geology graduate from SOSOC, picked up the first 30 samples of drill cuttings for identification.

The well profile to date is as follows:

- 0- 2 feet: boulders and yellow clay fill
- 2- 3 feet: yellow clay
- 3- 8 feet: black decomposed clay
- 8-22 feet: coarse brown sand
- 22-36 feet: green clay
- 36-161 feet: sticky gray clay
- 161-163 feet: hard gray shale
- 163-211 feet: sticky brown clay
- 211-214 feet: hard gray shale
- 214-309 feet: brown shale
- 309-310 feet: black decomposed shale
- 310-317 feet: black shale

There appears to be little correlation with other wells in the area.

Handwritten signature: John W. Lund
John W. Lund
Civil Engineer

2180 Sloan St.
Klamath Falls, OR

MODOC LUMBER COMPANY
GEOTHERMAL WELL DRILLING PROJECT

Weekly Report for: August 10-14, 1981

Began drilling with 8-3/4-inch diameter bit (8-inch net pay diameter) below bottom of 12-inch diameter casing. Initially the drilling was still into hard fractured basalt, however on Tuesday and Wednesday some clay and shale layers were encountered allowing the drilling rate to increase. At approximately 600 feet in depth a 10-20 gpm artesian flow of 78° F water was encountered. Thursday and Friday the drilling was into a hard unfractured basalt, slowing the rate considerably.

A total of 322 feet was drilled this week to a depth of 639 feet below the surface. A total of 86 sacks of drilling mud was used. The drilling rate for each day is as follows:

Monday: 36 feet
Tuesday: 119 feet
Wednesday: 142 feet
Thursday: 17 feet
Friday: 8 feet

Two temperature profiles were taken inside the drilling rods. The first was on Tuesday, giving a maximum temperature of 87.8° F at 320 feet (probably influenced by heat from cement hydration in the casing). The second was on Friday, giving a maximum temperature of 80.6° F at 620 feet. The drill string was pulled on Friday afternoon in preparation for a temperature profile measurement on Monday (one hour of standby time).

The drilling profile is as follows:

317-323 black basalt with white streaks of calcium
323-375 hard gray basalt
375-380 brown shale
380-410 black basalt
410-412 black clay
412-420 black basalt
420-494 brown clay
494-545 sticky yellow clay
545-551 hard brown shale
551-614 black basalt (hard with broken streaks)
614-639 hard gray basalt

John W. Lund
Civil Engineer

MODOC LUMBER COMPANY
GEOTHERMAL WELL DRILLING PROJECT

Progress report for week of August 16-22, 1981

A temperature profile was run on Monday Am to 639 feet inside the casing with the drill steel removed. The profile was as follows (two hours of standby time used):

135 ft.	77.2° F
235 ft.	77.5° F
335 ft.	78.1° F
435 ft.	78.6° F
535 ft.	78.8° F
585 ft.	79.2° F
635 ft.	80.4° F

The artesian flow remained around 10-20 gpm and varying from 76° to 78° F.

Extremely hard drilling in a gray basalt at the beginning of the week. Finally broke through into softer material on Wednesday at 679 feet. Had anticipated renting 300 feet of 5-1/2 inch drill collars from Portland to help increase the drilling rate. Modoc agreed to contribute \$1000 towards the rental. By Wednesday afternoon it was decided that the drill collars were not necessary. By Friday afternoon the 1000 foot depth was reached. It was agreed to proceed beyond 1000 feet to the first hard material. Thus, drilling stopped at 1063 feet in a hard gray basalt. The mud pit dropped four inches while drilling around 1060 feet, probably due to lost circulation. The contractor measured a mud temperature of 90° F at the close of work on Friday.

The drilling profile for the week was:

639-679 feet:	hard gray basalt
679-692	decomposed black basalt
692-695	hard brown shale with clay streaks
695-706	brown clay
706-874	gray clay
874-878	decomposed black basalt
878-914	hard black basalt
914-918	brown clay
918-941	gray clay
941-949	brown basalt
949-1032	gray clay
1032-1053	red clay
1053-1059	red ash
1059-1063	hard gray basalt

A total of 53 sacks of mud were used.

An interrump geology report (to 639 feet) was completed by Dennis Glover from Ashland. He noted in his conclusions that low grade hydrothermal alterations were observed first at the 410-420 foot level (in shale and basalt). Alterations were also observed in the basalts between 530 and 630 feet.

The total cost to date (excluding the 12-inch diameter casing cost) is \$36,784.79.

John W. Lund
Civil Engineer

MODOC LUMBER CO.
GEOTHERMAL WELL DRILLING PROJECT

Progress report for the week of August 23, 1981 to August 29, 1981

The Contractor was given written approval to continue drilling to a maximum depth of 1500 feet. The cost items were to remain as in the original contract with no additional bonding required. Continued drilling with the 8-3/4-inch diameter bit into hard basalt at a very slow rate. Pulled drilling string Tuesday PM to inspect bit, which was in good shape. Discovered hole in pump seat on Wednesday AM, and thus were shut down all day Wednesday and Thursday for repairs. Started drilling again on Friday with 7-7/8-inch diameter bit. The drilling rate and profile are as follows:

Rate

Monday:	20 feet
Tuesday:	22 feet
Wednesday:	0
Thursday:	0
Friday:	<u>15 feet</u>
Total:	57 feet

Profile

1063-1069 feet	broken gray basalt
1069-1075 feet	black basalt
1075-1083 feet	broken gray basalt
1083-1120 feet	hard gray basalt

The artesian flow is still around 10-20 gpm at 78° F. Two temperature profiles were taken during the week; one on Monday morning inside the drill stem (maximum temperature on the bottom at 1060 feet of 91.6° F); and one on Wednesday morning with the drill stem removed (maximum temperature on the bottom at 1105 feet of 93.2° F. The temperature profiles from both measurements matched, with the following results:

<u>depth (ft)</u>	<u>temp. (°F)</u>	<u>depth</u>	<u>temp.</u>
100	79.0	800	86.7
200	79.3	900	88.9
300	79.5	950	89.6
400	80.2	1000	90.3
500	80.4	1050	91.6
600	80.9	1100	92.8
700	83.5	1105	93.2

No new flows have been detected. A total of four (4) hours standby time were authorized this week and no new drilling mud was used.

The Contractor submitted a bill for the work to 1063 feet for a total of \$36,784.79. The bill was verified by the Engineer and paid on Wednesday by Modoc (less 10%).

John W. Lund
Civil Engineer

MODOC LUMBER CO.
GEOTHERMAL WELL DRILLING PROJECT

Progress report for the week of August 30 - September 5, 1981

Continued drilling into hard broken basalt, however by late Tuesday broke through into softer material. Drill collars were delivered from Portland, and 300 feet of length added to the drill string on Thursday morning. Reached 1500 feet in depth on Thursday, and the Contractor was given the authority to drill up to 1700 feet with no changes in the contract bid prices. Late Thursday the mud pump broke down, and remained shut down through Friday while repairs were being made.

The artesian flow remained about the same (10-20 gpm), however the temperature increased from 78° to 80° F during the week. The mud temperature was around 92° F. A slight lost circulation zone was encountered at 1380 feet.

The drill rate and profile for the week was as follows:

<u>Day</u>	<u>Rate</u>
Monday:	28 ft.
Tuesday:	148 ft.
Wednesday:	206 ft.
Thursday:	81 ft.
Friday:	0

<u>Depth</u>	<u>Description</u>
1120-1155	hard broken gray basalt
1155-1176	welded tuff??
1176-1215	brown shale
1215-1293	brown clay
1293-1508	brown clay with streaks of shale
1508-1580	hard brown shale

No mud used during the week. A group of Japanese geothermal engineers from NEDO visited the site on Wednesday. DOE representatives were briefed on the project and visited the site on Thursday.

The total Contractor cost to 1500 feet is \$52091.43 (\$15,306.64 since the last billing). The estimated cost to 1700 feet is \$8000.

John W. Lund
Civil Engineer

* 18w'

MODOC LUMBER CO.
GEOTHERMAL WELL DRILLING PROJECT

Progress report for week of 6-13 September, 1981

Monday was a holiday. Tuesday still working on pump (replacing gear teeth). Temperature profile taken at 1550 feet on Tuesday gave a maximum reading of 135° F (inside drill stem). Began drilling again on Wednesday and Contractor given verbal authority to continue beyond 1700 feet. Temperature taken at 1750 feet (141° F) and at 1800 feet (146° F), Contractor given authority to continue beyond 1831 feet at \$200 per hour. Continued drilling at this cost rate through Friday PM to 2017 feet. At 1900 feet encountered a broken shale where a lost circulation zone was encountered. Broken basalt encountered from 1912 feet. Finally stopped drilling in a hard gray basalt.

The artesian flow continued at 10-20 gpm and at 82° F. Drilling mud temperature varied from 96 -104° F.

Late PM on Friday, began pulling drill steel in anticipation of open-hole temperature profile on Monday.

A total of 80 sacks of mud used. Six hours of standby time used and 18-1/2 hours of drilling time at \$200 per hour.

Drilling rate and profile as follows:

<u>Day</u>	<u>Rate</u>
Tuesday	0
Wednesday	251 feet
Thursday	90 feet
Friday	<u>150 feet</u>
Total	491 feet

<u>Depth</u>	<u>Description</u>
1580-1847	brown shale
1847-1900	gray shale
1900-1912	broken gray shale (ash)
1912-1935	hard broken black basalt
1935-1992	black basalt
1992-2041	hard broken black basalt
2041-2071	hard gray basalt

The temperature profile on Tuesday is as follows:

<u>Depth</u>	<u>Temp.</u>	<u>Depth</u>	<u>Temp.</u>
100 ft.	80.2° F	1000	96.3
200	80.6	1050	96.6
300	80.8	1100	97.3
400	82.0	1200	101.1
500	82.4	1300	109.9
550	83.1	1350	114.3
600	85.8	1400	119.3
700	89.8	1450	124.3
800	93.7	1500	131.4
900	95.2	1550	135.0
		1555	135.1

The temperature profile on Thursday is as follows:

<u>Depth</u>	<u>Temp.</u>
900 Ft.	91.8° F
1300	104.2
1400	112.5
1500	118.0
1600	127.4
1700	136.8
1750	140.7
1800	146 (corrected thermometer)

These latter two gradients give approximately 8° F/ 100 feet.

John W. Lund
Civil Engineer

MODOC LUMBER CO.

Geothermal Well Drilling Project

Progress Report for the Week of September 13-19, 1981

The Contractor finished pulling the drill steel from the well on Monday and the Engineer attempted to take a temperature profile with USGS equipment. Were unable to obtain the profile, but did get a bottom hole temperature of 193° F with a maximum reading thermometer. Began the pump test on Tuesday with the pump bowls set at 200 feet. The discharge water cleared up within two hours of pumping. The maximum pumping rate obtained was 300 gpm, which finally stabilized at 275 gpm with 195 feet of draw-down. The temperature varied from 73-74° F. Varied the pumping rate and surged the well several times. Pumped 22-1/2 hours total. The various pumping rates were:

<u>gpm</u>	<u>draw-down</u>	<u>temperature</u>
155	111 feet	73° F
215	155 feet	73° F
275	195 feet	73-74° F

Again attempted to take temperature profile after the pump test with the USGS equipment. The equipment did not function properly, but did obtain a bottom hole temperature at 2065-1/2 feet of 200° F (with thermometers).

Capped well on Wednesday with drain pipe on side and plug on top. Began dismantling equipment on Thursday and removed the majority of the equipment from the site on Friday.

The well shut-in pressure was measured at 2 psig.

John W. Lund
Civil Engineer

MODOC LUMBER CO.
Geothermal Well Drilling Project

Progress Report for the Week of September 20-26, 1981

The Contractor finished moving the equipment from the site on Monday and filled in the mud pits on Tuesday. Temperature profile, gamma, resistivity and spontaneous potential logs were run by the Department of Geology and Mineral Industries on Tuesday. Bottom hole temperature of 189° F at 2065 feet was obtained. This agrees with the corrected ($200 - 10.5 \times 0.5 = 189-1/2^{\circ}$ F) maximum reading taken by thermometer on September 16th. The temperature gradient the last 700 feet was 11° F per 100 feet. The well was flowing through the side pipe at 25 gpm at 74° F.

The Contractor submitted a final total billing of \$72,619.49 of which \$35,834.70 was the balance due. He also submitted the final log and pump test results.

John W. Lund
Civil Engineer

Appendix J

COMMERCIAL-SCALE DRYER DATA

In order to determine feedstock dryer requirements and performance expectations, the following profiles were calculated to show the comparative effects of using dry fuel, blended wet and dry fuel, and wet hogged fuel as heat sources for the dryer.

This data indicates a major difference in the amount of blend air required to reduce input temperatures to a suitable level for injection into the dryer; in order to avoid blue haze conditions, a maximum temperature of 700°F is expected. Blended fuel at 30% moisture content is the resulting recommendation for dryer planning.

The dryer profiles are based on six ton per hour production, or 32,000 tons per year. The performance figures and gas volumes can be roughly doubled to allow for installation of a second pellet mill. Drying costs are assumed to be essentially equal to feedstock costs for these calculations, i.e. \$7.50 per BDT.

PM DATA 50.1
FUEL DRYER DATA FOR PELLET MILL OPERATIONS

PLEASE CHECK YOUR INPUTS :

DRYER INLET TEMPERATURE SET AT.....	TSET, F	=	700.00
MOISTURE CONTENT OF INPUT HOGGED FEEDSTOCK.....	WMC, %WB	=	45.00
MOISTURE CONTENT REQUIRED AT DRYER EXIT.....	DMC, %WB	=	10.00
AMBIENT AIR TEMPERATURE.....	TA, F	=	60.00
DRYER EXHAUST TEMPERATURE.....	TB, F	=	250.00
DRYER OUTPUT REQUIRED AT DMC MC%,WB.....	TON/HR	=	6.00
EXHAUST GAS RECYCLING SELECTED.....	RCY, %	=	0.00
COST OF RAW MATERIAL.....	COST, \$/TON WB	=	7.50
FUEL MOISTURE CONTENT SELECTED.....	FMC	=	30.00

FUEL MC = 30 RCY% = 0

COST OF DRIED PRODUCT (INCLUDES FUEL COST + COST OF DRYING THE FUEL).....	\$/TON @ 10%MC(WB)	\$ =	15.07
TOTAL RAW MATERIAL USED TO OBTAIN PRODUCT AND FUEL.....	TS, TONS/HR	=	12.06
RAW MATERIAL @ WMC USED AS PRODUCT.....	MIN, TONS/HR	=	9.82
RAW MATERIAL @ WMC USED FOR FUEL.....	MIN, TONS/HR	=	2.09
BLENDED FUEL FIGURES :			
FUEL MASS @ FMC.....	FUEL, TONS/HR	=	1.64
COMPOSED OF :			
WET BLEND FUEL USED @ 45%MC(WB).....	IP, TONS/HR	=	1.02
DRY BLEND FUEL USED @ 10%MC(WB).....	IO, TONS/HR	=	.62
DRY:WET FUEL BLENDING RATIO / LB OF FUEL @ 30 %MC(WB).....	BR,	=	38 : 62
FUEL USED (OVEN DRY SOLIDS)	DFW, TONS/HR	=	1.15
HIGHER HEATING VALUE OF FUEL.....	HHV,BTU/LB	=	8,500.00
HEAT CONTENT OF RECYCLE GAS (PER UNIT OF DD SOLIDS).....	HVG, BTU/LB	=	0.00

FUEL MOISTURE AS GAS.....	FWVOL, SCFM	=	365.37
COMBUSTION AIR (STOICH).....	CA, SCFM	=	3,407.78
PRIMARY COMBUSTION TEMPERATURE @25% EXCESS AIR (PRIOR TO BLEND AIR.....	TX	=	1,924.80
EXCESS AND BLEND AIR (INCLUDES GAS RECYCLE).....	EA, SCFM	=	18,848.87
TOTAL COMBUSTION AIR,EXCESS AND BLEND AIR TO DELIVER.....	SCFM	=	22,256.64
TOTAL GAS TO DRYER (TEMP CORRECTED TO TF).....	BVBO, ACFM	=	50,261.12
ACTUAL INLET TEMPERATURE.....	TF, F	=	682.20
TOTAL DRYER EXHAUST GAS @ TB.....	DOV, ACFM	=	34,609.39
COMPOSED OF :			
WATER REMOVED.....	PWVOL, ACFM	=	3,366.84
COMBUSTION GASES ETC,.....	PGVOL, ACFM	=	31,242.55

TOTAL HEAT INPUT (FUEL CONSUMED + GAS RECYCLE).....	THI, BTU*10 ⁰⁶	=	21.86
COMPOSED OF :			
HEAT ENERGY IN COMBUSTION GASES,EXCESS AND BLEND AIR, EXHAUSTING @ TB.....	Q1, BTU*10 ⁰⁶	=	5.81
HEAT ENERGY IN MOISTURE REMOVED.....	Q2, BTU*10 ⁰⁶	=	11.73
HEAT ENERGY IN PRODUCT EXIT THE DRYER.....	Q3, BTU*10 ⁰⁶	=	1.48
HEAT ENERGY LOSS : CONDUCTION AND RADIATION : BURNER.....	Q4, BTU*10 ⁰⁶	=	1.09
HEAT ENERGY LOSS : CONDUCTION AND RADIATION : DRYER.....	Q5, BTU*10 ⁰⁶	=	1.75
ERROR CHECK (Q1+Q2+Q3+Q4+Q5) SHOULD BE APPROX. THI.....	ECHECK	=	PLEASE CHECK

WATER REMOVED (PRODUCT AND FUEL IF DRY OR BLENDED FUEL USED).....	WR,LBS	=	9,613.33
BTU USED PER LB OF WATER REMOVED.....	BTU/LB	=	2,274.05
SYSTEM HEATING EFFICIENCY.....	EFF,%	=	53.65

FM DATA SQ. 1
FUEL DRYER DATA FOR PELLET MILL OPERATIONS

PLEASE CHECK YOUR INPUTS :

DRYER INLET TEMPERATURE SET AT.....	TSET, F	=	700.00
MOISTURE CONTENT OF INPUT HOGGED FEEDSTOCK.....	WMC, %WB	=	45.00
MOISTURE CONTENT REQUIRED AT DRYER EXIT.....	DMC, %WB	=	10.00
AMBIENT AIR TEMPERATURE.....	TA, F	=	60.00
DRYER EXHAUST TEMPERATURE.....	TB, F	=	250.00
DRYER OUTPUT REQUIRED AT DMC MC%,WB.....	TON/HR	=	6.00
EXHAUST GAS RECYCLING SELECTED.....	RCY, %	=	0.00
COST OF RAW MATERIAL.....	COST, \$/TON WB	=	7.50
FUEL MOISTURE CONTENT SELECTED.....	FMC	=	10.00

FUEL MC = 10 RCY% = 0

COST OF DRIED PRODUCT (INCLUDES FUEL COST + COST OF DRYING THE FUEL).....	\$/TON @ 10%MC(WB)	\$ =	15.32
TOTAL RAW MATERIAL USED TO OBTAIN PRODUCT AND FUEL.....	TS, TONS/HR	=	12.25
RAW MATERIAL @ WMC USED AS PRODUCT.....	MIN, TONS/HR	=	9.82
RAW MATERIAL @ WMC USED FOR FUEL.....	MIN, TONS/HR	=	2.31
FUEL USED (OVEN DRY SOLIDS)	DFW, TONS/HR	=	1.27
HIGHER HEATING VALUE OF FUEL.....	HHV, BTU/LB	=	8,500.00
HEAT CONTENT OF RECYCLE GAS (PER UNIT OF OD SOLIDS).....	HVG, BTU/LB	=	0.00

FUEL MOISTURE AS GAS.....	FWVOL, SCFM	=	104.97
COMBUSTION AIR (STOICH).....	CA, SCFM	=	3,776.12
PRIMARY COMBUSTION TEMPERATURE @25% EXCESS AIR (PRIOR TO BLEND AIR).....	TX	=	2,152.63
EXCESS AND BLEND AIR (INCLUDES GAS RECYCLE).....	EA, SCFM	=	21,835.57
TOTAL COMBUSTION AIR, EXCESS AND BLEND AIR TO DELIVER.....	SCFM	=	25,611.69
TOTAL GAS TO DRYER (TEMP CORRECTED TO TF).....	BVBO, ACFM	=	57,263.99
ACTUAL INLET TEMPERATURE.....	TF, F	=	685.08
TOTAL DRYER EXHAUST GAS @ TB.....	DOV, ACFM	=	39,244.55
COMPOSED OF :			
WATER REMOVED.....	FWVOL, ACFM	=	3,738.29
COMBUSTION GASES ETC.....	PGVOL, ACFM	=	35,506.26

TOTAL HEAT INPUT (FUEL CONSUMED + GAS RECYCLE).....	THI, BTU*10 ⁰⁶	=	24.22
COMPOSED OF :			
HEAT ENERGY IN COMBUSTION GASES, EXCESS AND BLEND AIR, EXHAUSTING @ TB.....	Q1, BTU*10 ⁰⁶	=	6.41
HEAT ENERGY IN MOISTURE REMOVED.....	Q2, BTU*10 ⁰⁶	=	13.02
HEAT ENERGY IN PRODUCT EXIT THE DRYER.....	Q3, BTU*10 ⁰⁶	=	1.65
HEAT ENERGY LOSS : CONDUCTION AND RADIATION : BURNER.....	Q4, BTU*10 ⁰⁶	=	1.21
HEAT ENERGY LOSS : CONDUCTION AND RADIATION : DRYER.....	Q5, BTU*10 ⁰⁶	=	1.94
ERROR CHECK (Q1+Q2+Q3+Q4+Q5) SHOULD BE APPROX. THI.....	ECHECK	=	PLEASE CHECK

WATER REMOVED (PRODUCT AND FUEL IF DRY OR BLENDED FUEL USED).....	WR, LBS	=	10,673.94
BTU USED PER LB OF WATER REMOVED.....	BTU/LB	=	2,269.47
SYSTEM HEATING EFFICIENCY.....	EFF, %	=	53.76

FM DATA 50.1
FUEL DRYER DATA FOR PELLET MILL OPERATIONS

PLEASE CHECK YOUR INPUTS :

DRYER INLET TEMPERATURE SET AT.....	TSET, F	=	700.00
MOISTURE CONTENT OF INPUT HOGGED FEEDSTOCK.....	WMC, %WB	=	45.00
MOISTURE CONTENT REQUIRED AT DRYER EXIT.....	DMC, %WB	=	10.00
AMBIENT AIR TEMPERATURE.....	TA, F	=	60.00
DRYER EXHAUST TEMPERATURE.....	TB, F	=	250.00
DRYER OUTPUT REQUIRED AT FMC MC%,WB.....	TON/HR	=	6.00
EXHAUST GAS RECYCLING SELECTED.....	RCY, %	=	0.00
COST OF RAW MATERIAL.....	COST, \$/TON WB	=	7.50
FUEL MOISTURE CONTENT SELECTED.....	FMC	=	45.00

FUEL MC = 45 RCY% = 0

COST OF DRIED PRODUCT (INCLUDES FUEL COST + COST OF DRYING THE FUEL).....	\$/TON @ 10%MC(WB)	\$ =	14.58
TOTAL RAW MATERIAL USED TO OBTAIN PRODUCT AND FUEL.....	TS, TONS/HR	=	11.66
RAW MATERIAL @ WMC USED AS PRODUCT.....	MIN, TONS/HR	=	9.82
RAW MATERIAL @ WMC USED FOR FUEL.....	MIN, TONS/HR	=	1.84
FUEL USED (OVEN DRY SOLIDS)	DFW, TONS/HR	=	1.01
HIGHER HEATING VALUE OF FUEL.....	HHV, BTU/LB	=	8,500.00
HEAT CONTENT OF RECYCLE GAS (PER UNIT OF OD SOLIDS).....	HVG, BTU/LB	=	0.00

FUEL MOISTURE AS GAS.....	FWVOL, SCFM	=	615.47
COMBUSTION AIR (STOICH).....	CA, SCFM	=	3,006.85
PRIMARY COMBUSTION TEMPERATURE @25% EXCESS AIR (PRIOR TO BLEND AIR).....	TX	=	1,705.00
EXCESS AND BLEND AIR (INCLUDES GAS RECYCLE).....	EA, SCFM	=	15,119.37
TOTAL COMBUSTION AIR, EXCESS AND BLEND AIR TO DELIVER.....	SCFM	=	18,126.23
TOTAL GAS TO DRYER (TEMP CORRECTED TO TF).....	BVBO, ACFM	=	42,107.44
ACTUAL INLET TEMPERATURE.....	TF, F	=	694.18
TOTAL DRYER EXHAUST GAS @ TB.....	DOV, ACFM	=	28,898.06
COMPOSED OF :			
WATER REMOVED.....	FWVOL, ACFM	=	2,995.39
COMBUSTION GASES ETC.....	PGVOL, ACFM	=	25,902.67

TOTAL HEAT INPUT (FUEL CONSUMED + GAS RECYCLE).....	THI, BTU*10 ⁰⁶	=	19.29
COMPOSED OF :			
HEAT ENERGY IN COMBUSTION GASES, EXCESS AND BLEND AIR, EXHAUSTING @ TB.....	Q1, BTU*10 ⁰⁶	=	5.03
HEAT ENERGY IN MOISTURE REMOVED.....	Q2, BTU*10 ⁰⁶	=	10.43
HEAT ENERGY IN PRODUCT EXIT THE DRYER.....	Q3, BTU*10 ⁰⁶	=	1.32
HEAT ENERGY LOSS : CONDUCTION AND RADIATION : BURNER.....	Q4, BTU*10 ⁰⁶	=	.96
HEAT ENERGY LOSS : CONDUCTION AND RADIATION : DRYER.....	Q5, BTU*10 ⁰⁶	=	1.54
ERROR CHECK (Q1+Q2+Q3+Q4+Q5) SHOULD BE APPROX. THI.....	ECHECK	=	PLEASE CHECK

WATER REMOVED (PRODUCT AND FUEL IF DRY OR BLENDED FUEL USED).....	WR, LBS	=	8,552.73
BTU USED PER LB OF WATER REMOVED.....	BTU/LB	=	2,255.33
SYSTEM HEATING EFFICIENCY.....	EFF, %	=	54.09

Appendix K

PILOT PLANT SAFETY REPORT

March 17, 1982

Mr. Howard Johnson
MODOC LUMBER CO.
PO Box 257
Klamath Falls OR 97601

Dear Mr. Johnson:

During my visit to your Klamath Falls operation, I made a resurvey of your new pellet plant. I noted that all discrepancies had been corrected as we had agreed upon.

In addition, I checked on the noise level emission with negative findings and also checked on the dust emission of the California pellet mill.

All employees were wearing dust masks at the time of my visit. Your concern of the dust level was unwarranted. Your suggested covering of the infeed conveyors would eliminate a majority of the existing dust.

I feel that the dust present creates only a nuisance rather than a health hazard.

If I can be of any other assistance to you, please contact me.

Sincerely,

TOM WINTERS
Loss Control Consultant

TW:rk

Safety is a responsibility of your management. Our calls are intended to assist you. Recommendations are developed from conditions observed at the time of our visits. They do not necessarily include every possible loss potential, code violation or exceptions to good practice.

Appendix L

TAX INCENTIVES APPLICABLE TO A DBF PROJECT IN OREGON

The federal and state tax incentives which are applicable to a DBF project in Oregon are summarized as follows:

Federal Incentives

1. Investment Credit

Internal Revenue Code (IRC) Section 46 covers the regular investment tax credit. The 10 percent credit is available to certain tangible property which includes your DBF equipment except for the buildings.

2. Energy Property Investment Credit

The DBF equipment qualifies as "biomass property" under IRC Section 48. Biomass property, in turn, qualifies for a 20 percent energy property investment tax credit until December 1, 1985. However, special rules apply to property financed by "subsidized energy financing," i.e. grants. In such cases, the energy investment credit percentage is reduced to 5 percent until January 1, 1983. Between January 1, 1983 and December 1, 1985 the energy percentage is determined by the following formula:

$$\text{Qualified investment} \times 1 - \left(\frac{\text{portion of qualified investment allocable to grants}}{\text{qualified investment}} \right)$$

The energy tax credit is in addition to any other investment tax credit available to the taxpayer.

3. Credit for Fuel from Nonconventional Fuel Source

This IRC Section outlines a credit equal to \$3.00 multiplied by the barrel oil equivalent of qualified fuels sold by the taxpayer, the production of which is attributable to the taxpayer. Pellets qualify as processed wood fuels under the IRS definition. A complex "phase-out" formula reducing this credit does not apply the first three years of production, due to the pellets being a qualified processed wood fuel. The credit is reduced by the same formula given above under the energy investment credit. In addition, any amount claimed under the energy investment credit is deducted from the total fuel credit as determined in this Section.

4. Additional First-Year Allowance

The DBF equipment, being purchased for use in production of income, qualified for this allowance covered in IRC Section 179. The allowance is in addition to the regular depreciation. The allowance is 20 percent of the cost of qualified property, but is subject to a dollar limitation of \$2,000 (20 percent of \$10,000).

State Incentives

1. Additional Depreciation Allowance

Oregon Revised Statute 317.285(6) allows for claiming an additional depreciation allowance according to the guidelines of Federal IRC section 179. If you qualify for the Federal allowance, then you qualify for the state additional allowance for the same percent.

2. Economically Lagging Area Investment Credit

According to Oregon Administrative Rule 123-14-005, investments that qualify for this 10 percent tax credit must both broaden the region's economic base and directly result in one of several activities. Additionally, the project must be reasonably expected to provide new jobs as determined by the ratio of \$50,000 of investment per job. The Rule states that investments to expand the scope of an investment in progress are eligible if the decision to expand is made subsequent to formal Economic Development Commission action.

3. Energy Conservation Facility Credit

The state Energy Conservation Facility Tax Credit (ORS 469) applies to those processes that:

- (a) Replace a substantial part of an existing use of electricity, petroleum or natural gas;
- (b) Provide the initial use of energy where electricity, petroleum or natural gas would have been used;
- (c) Generate electricity to replace an existing source of electricity or to provide a new source of electricity for use in the trade or business; or
- (d) Perform a process that obtains energy from material that would otherwise be solid waste as defined in ORS 459.005.

There are no employee size stipulations in the law. It appears that your future customers could be potential applicants under this program. As such, this credit is an excellent sales incentive.

It should be noted that these are general observations about a complex area of tax law, and any proposed transactions should first be reviewed by tax counsel.